

NATIONAL ADVISORY COMMITTEE FOR AERONAUTICS

TECHNICAL NOTE 3192

EXPERIMENTAL STRESS ANALYSIS OF STIFFENED
CYLINDERS WITH CUTOUTS

SHEAR LOAD

By Floyd R. Schlechte and Richard Rosecrans

Langley Aeronautical Laboratory
Langley Field, Va.



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SUMMARY

A cylindrical semimonocoque shell of circular cross section was mounted as a cantilever and loaded by a direct shear at the tip. The cylinder was tested with no cutout, with a rectangular cutout on the tension side, and with the cutout centered on the neutral axis on one side of the cylinder. The cutout was successively enlarged through six sizes varying from 30° to 130° in circumference and from 1 to 2 bays in length. Strain measurements were made with resistance-type wire strain gages near the cutout on the stringers, the skin, and the rings for each case, and the stresses obtained are presented in tables.

INTRODUCTION

Stresses obtained in torsion tests of a stiffened circular cylinder with a cutout are given in reference 1 and stresses found in pure bending tests of the same cylinder are given in reference 2. The present report, which is the last on this series of tests, gives results for two loading cases: shear load with the cutout on the tension side of the cylinder and shear load with the cutout centered on the neutral axis. In this report the cutout centered on the neutral axis is called a side cutout.

Results of related experimental work by other investigators are given in references 3 to 5. Reference 3 gives some data for stresses around cutouts for a series of tests of a cylinder loaded by torque or direct shear. Only shear stresses are given for the tests of the cylinder under torque loading, and only axial stresses are given for the tests with direct shear loading. Reference 4 gives stringer stresses and shear stresses in a circular cylindrical shell with two opposing side cutouts and loaded by direct shear and torque. Reference 5 presents experimental and theoretical studies of stresses in a fuselage model loaded by direct shear and having two opposing side cutouts.

TEST SPECIMEN AND PROCEDURE

Although the test specimen was the same one as that used in reference 1, a description of the cylinder is repeated here for completeness of the present paper. The test cylinder, which is shown in figure 1, consisted of a 24S-T aluminum-alloy skin 0.051 inch thick, 36 external $3/4 \times 3/4 \times 3/32$ angle stringers with cross-sectional area of 0.1373 square inch, and 8 equally spaced 24S-T aluminum-alloy Z-section rings with cross-sectional area of 0.4413 square inch. The rings were made of 1/8-inch sheet and were 2 inches deep with 1-inch flanges. The moment of inertia of the cylinder about a diameter was calculated to be 1119.3 in.⁴. After an initial test of the cylinder without a cutout, the series of cutout tests began with a cutout 1 bay in length by 30° in circumference. In four succeeding tests, the cutouts were 1 bay long and varied up to 130° in circumference. A final test was made with a cutout 2 bays long by 130° in circumference. The size of the cutout for each test is given in table 1.

The test procedure was analogous to that used in the tests of references 1 and 2. The cylinder was mounted on a heavy ring which was bolted to a rigid support. (See fig. 2.) Load was applied to a steel bulkhead at the tip by means of a hydraulic jack. The tip bulkhead was attached to the cylinder by a steel sleeve so that the distance from the end of the specimen to the point of load application was $12\frac{1}{8}$ inches.

Baldwin SR-4 wire strain gages mounted near the cutout on the stringers, skin, and rings were used for obtaining all the strain measurements. Type A-12 gages were used on the stringers and rings and type AR-1 rosette gages were used on the skin. Typical gage mountings are shown in figure 3. Stringer gages were mounted along the inside corner of the stringer angle, either at the rings or halfway between rings. Rosette gages were mounted either halfway between rings or $1\frac{1}{4}$ inches from a ring. In each rosette, two gages mounted at angles of 45° and 135° to the axis of the cylinder were used to measure the shear strain. Ring gages were mounted near the neutral axis of the ring cross section and on both flanges. The gage pattern in figure 4(a) shows the location of all the strain gages used in tests 2 to 6. The angular coordinate θ is measured from the center line of the cutout. All the gages shown were used in the test with a 30° cutout 1 bay long. For successive tests with a cutout 1 bay long, the cutout was enlarged by removing panels symmetrically located on either side of the longitudinal center line. All gages not cut away by enlarging the cutout were used in the next test. The gage pattern for test 7, with a 130° cutout 2 bays long, is shown in figure 4(b).

In each test, the maximum load was chosen to make the most highly strained gage indicate tension or compression of about 10,000 psi. This value was well below the buckling load in each test but was considered high enough to avoid the large relative errors associated with measurements of very small strains.

About 300 or 400 gages were read in each test, but the equipment available permitted only 80 gages to be read at one time. The procedure was as follows: A group of approximately 80 gages was read at each of four successively higher loads; then the first load was repeated as a check. If for some gages the original reading and the check reading differed by more than about 100 psi, the data for those gages were rejected and a test was performed for those gages only. Testing continued until satisfactory checks were obtained. If the temperature varied more than 1° F during a test run, the entire run was repeated. The reruns required only a small portion of the total testing time. After satisfactory data were obtained for a group of gages, another set of about 80 gages was read and the testing continued until all the gages had been read.

DATA REDUCTION AND ACCURACY

For each test, load was plotted against strain for the data from each gage, and the slope of a straight line through the test points determined the value taken as the strain at the maximum test load. Strains were converted to stresses with Young's modulus taken as 10,600,000 psi and the shear modulus as 4,000,000 psi. Tension is considered positive for normal stresses, and positive shear stresses are those that would be produced by a clockwise tip torque.

Because of symmetry, the stress at each longitudinal station at an angle θ° from the center line of the cutout should be the same as the one at $-\theta^\circ$; consequently, except for the cases noted in the next section, the stresses from symmetrically located gages were averaged. The final stresses were all reduced to correspond to stresses for a load of 2,000 pounds.

Errors in measuring the applied load include an uncertainty of 1 percent in the jack load and a small amount of friction in the loading frame. In addition, the strain gages may have inaccuracies of 200 psi at the loads of the actual tests or 3 percent, whichever is larger.

RESULTS

Stresses are presented in tables for all of the cutout tests and the actual maximum load used in each test is also given. Results of tests of the cylinder with the cutout on the tension side are given in tables 2 to 7 and results of tests of the cylinder with the cutout centered on the neutral axis (the side cutout) are given in tables 8 to 13. A test of the cylinder without a cutout gave stresses that were very close to those determined by elementary theory. Consequently, for the cutout tests, "stringer stresses due to cutout only" and "shear stresses due to cutout only" were calculated by subtracting from the measured stresses the stresses determined by ordinary beam theory for the uncut cylinder.

Each table gives a set of stresses for one test corresponding to a certain cutout size and loading condition. In each table, stringer stresses are given in part (a) and "stringer stresses due to cutout only" are given in part (b). Shear stresses are presented in part (c) and "shear stresses due to cutout only" are presented in part (d). Finally, the ring stresses are given in part (e). When stringer stresses that might be averaged differed by more than 1,000 psi at the actual test load, both values instead of the average value are given in the tables. For these cases, the numbers giving the stresses from the region where θ is negative are in parentheses, but the signs are chosen as if these stresses were in the region where θ is positive. Ring stresses for the case of shear load on the cylinder with a side cutout were not averaged because they were very inconsistent. In several instances, values of stress that were from obviously inaccurate gage readings were omitted from the tables.

The stress distributions around the cutout are presented in figures 5 to 8. Stresses for shear load with the cutout on the tension side of the cylinder are given for the 30° cutout in figure 5 and for the 90° cutout in figure 6. Stresses for shear load with the side cutout are presented for the 30° cutout in figure 7 and for the 90° cutout in figure 8. Figures 5 to 8 have four parts each, corresponding to parts (a), (b), (c), and (d) of the tables. The test points, which are represented by the height of the heavy vertical lines, are joined by straight lines to give a pictorial view of the stress field. In the figures showing shear stresses, the lines joining points on opposite sides of the coaming stringer near the cutout have been broken because a straight line is not very accurate in this region.

CONCLUDING REMARKS

Stresses obtained in a series of tests of a stiffened cylindrical shell with a cutout subjected to a tip shear are presented in tables. The data presented are intended primarily to serve as a check on methods of analysis or as a guide to the development of such methods. Consequently, no attempt has been made in this paper to interpret the data or draw conclusions therefrom.

Langley Aeronautical Laboratory,
National Advisory Committee for Aeronautics,
Langley Field, Va., March 12, 1954.

REFERENCES

1. Schlechte, Floyd R., and Rosecrans, Richard: Experimental Stress Analysis of Stiffened Cylinders With Cutouts - Pure Torsion. NACA TN 3039, 1953.
2. Schlechte, Floyd R., and Rosecrans, Richard: Experimental Stress Analysis of Stiffened Cylinders With Cutouts - Pure Bending. NACA TN 3073, 1954.
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4. Henson, G. S.: Stress Distribution Near a Rectangular Cut-Out in a Reinforced Circular Cylinder Due to Direct Shear Loading and Torque. Part I - Test Results. Rep. No. 51, College of Aero., Cranfield (British), Jan. 1952.
5. Butler, S., and Butterworth, F. E.: Type 167 Shear Tests on Half Scale Fuselage With Entrance Door Cut-Outs. S & M Memo. No. 6/50 (Rep. No. C. R. 539), The Bristol Aeroplane Co., Ltd., Jan. 1949.

TABLE 1.- CUTOUT SIZE

Test number	Length of cutout, bays	Width of cutout, deg
1	None	None
2	1	30
3	1	50
4	1	70
5	1	90
6	1	130
7	2	130

TABLE 2.- STRESSES AROUND CUTOUT OF 30° BY 1 BAY ON TENSION SIDE OF CYLINDER LOADED BY SHEAR
FORCE OF 2,000 POUNDS AT TIP (ACTUAL APPLIED LOAD, 7,200 POUNDS)

(a) Stringer stresses, psi

Distance from center line of cutout, in.

	30	24	18	12	6	0	6	12	18	24	30
15	928		580	0		0	1,075		2,203		
	972		1,445	2,329	2,974	2,937	2,126		2,150		
	988		1,581	1,966	2,212	2,334	2,203		2,203		
45	979		1,431	1,630	1,826	1,926	1,993		2,047		
	898		1,185	1,374	1,458	1,595	1,737		1,890		
	773		1,023	1,107	1,190	1,303	1,353		1,617		
75	583		746	822	892	947	1,063	1,115	1,263		
	392		486	530	542	595	707		828		
	-38		-103	-71	-118	-103	-162	-103	-77		
105											

TABLE 2.- STRESSES AROUND CUTOUT OF 30° BY 1 BAY ON TENSION SIDE OF CYLINDER LOADED BY SHEAR

FORCE OF 2,000 POUNDS AT TIP (ACTUAL APPLIED LOAD, 7,200 POUNDS) - Continued

(b) Stringer stresses due to cutout only, psi

		Distance from center line of cutout, in.										
		30	24	18	12	6	0	6	12	18	24	30
15	θ , deg	-209			-881	-1,623		-1,947	-1,034			-230
		-135			22	749	1,236	1,041	73			-219
		-55			241	477	574	548	268			-29
		32			214	279	340	305	237			21
45		75			128	200	167	186	211			130
100				158	147	134	151	107			177	
80				100	104	103	86	131	111		187	
75		74			78	77	43	51	118			148
		38			-5	38	1	27	-21	49	86	
105												

TABLE 2.- STRESSES AROUND CUTOUT OF 30° BY 1 BAY ON TENSION SIDE OF CYLINDER LOADED BY SHEAR

FORCE OF 2,000 POUNDS AT TIP (ACTUAL APPLIED LOAD, 7,200 POUNDS) - Continued

(c) Shear stresses, psi

		Distance from center line of cutout, in.											
		36	30	24	18	12	6	0	6	12	18	24	
θ, deg		51						32 56					
		142	82	-389	-800			1,319	778				
15					43	105	229	437	441	650			
	404		340		311	335	485	397	316	419	469		
45					559	530	570	561	486	477	452		
	610		641		700	671	645	635	640	576	558	649	623
					823	776	758	744	698	652			
75			835		870	813	815	801	770	756	661	757	
					862	835	824	830	846		755		
105			888		856	824	807	849	801	883	809	840	
						718		755	716		780		
135			557			525		571	525				
						339							
165								182	160				

TABLE 2.- STRESSES AROUND CUTOOUT OF 30° BY 1 BAY ON TENSION SIDE OF CYLINDER LOADED BY SHEAR

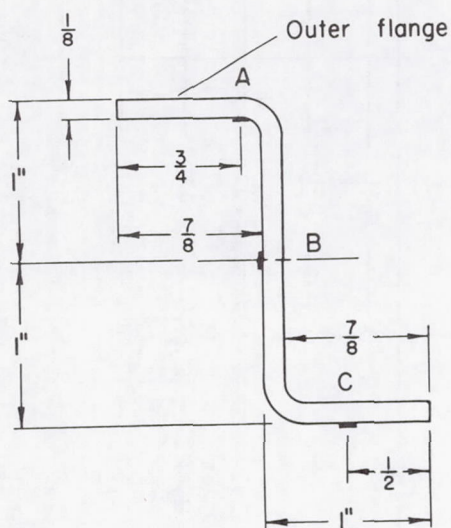
FORCE OF 2,000 POUNDS AT TIP (ACTUAL APPLIED LOAD, 7,200 POUNDS) - Continued

(d) Shear stresses due to cutout only

		Distance from center line of cutout, in.											
		36	30	24	18	12	6	0	6	12	18	24	
θ, deg		51				32				56			
		-1	-61	-532	-943					1,176	635		
15					-239	-177	-53	155	159	368			
	-8		-72	-101	-77	73	-15	-96	7	57			
				29	0	40	-31	-44	-53	-78			
45	-22		9	68	39	13	3	8	-56	74	17	-9	
				109	62	44	30	-16	-62				
	21		61	96	39	41	27	-4	-18		-113	-17	
75					50	23	12	18	34		-57		
	60		76	44	12	-5	37	-11	71		-3	28	
105													
					4		41	2			66		
135			27		-5		41	-5					
					57								
165							39	17					

TABLE 2.- STRESSES AROUND CUTOUT OF 30° BY 1 BAY ON TENSION SIDE
OF CYLINDER LOADED BY SHEAR FORCE OF 2,000 POUNDS AT
TIP (ACTUAL APPLIED LOAD, 7,200 POUNDS) - Concluded

(e) Ring stresses, psi



θ , deg	Ring 1			Ring 2		
	A	B	C	A	B	C
5	-71	-219	-266	-77	-321	-321
15	-197	-281	-107	-271	-315	-72
25	-157	-162	-1	-147	-136	51
35	-118	-51	0	-150	-52	106
45	-118	-31	59	-200	-16	146
55	-125	0	86	-166	-7	131
65	-91	0	52	-150	-3	90
75	-66	0	44	-111	9	37
85	0	0	0	-37	0	0
95	0	0	0	0	0	0

TABLE 3.- STRESSES AROUND CUTOUT OF 50° BY 1 BAY ON TENSION SIDE OF CYLINDER LOADED BY SHEAR

FORCE OF 2,000 POUNDS AT TIP (ACTUAL APPLIED LOAD, 5,000 POUNDS)

(a) Stringer stresses, psi

Distance from center line of cutout, in.

	30	24	18	12	6	0	6	12	18	24	30
15	566		202	0		0	594		1,755		
	691		492	0		0	878		1,895		
	776		1,344	2,724	3,511	3,759	2,332		1,963		
	910		1,658	2,094	2,421	2,546	2,430		2,001		
45	854		1,412	1,690	1,819	1,944	1,997		1,942		
	816		1,168	1,289	1,340	1,505	1,518		1,696		
	610		831	926	937	1,039	1,111	1,206	1,323		
75	471		458	572	568	610	700		912		
	0		-123	-85	-165	-132	-199	-98	-26		
105											

TABLE 3.- STRESSES AROUND CUTOUT OF 50° BY 1 BAY ON TENSION SIDE OF CYLINDER LOADED BY SHEAR

FORCE OF 2,000 POUNDS AT TIP (ACTUAL APPLIED LOAD, 5,000 POUNDS) - Continued

(b) Stringer stresses due to cutout only, psi

Distance from center line of cutout, in.												
	30	24	18	12	6	0	6	12	18	24	30	
15	-571		-1,259	-1,623			-1,947	-1,515		-678		
	-416		-931	-1,580			-1,896	-1,175		-474		
	-267		4	1,235	1,873	1,973	397			-269		
	-37		441	743	935	925	674			-25		
45	31		355	516	528	535	471			182		
	143		303	329	284	353	170			256		
	107		185	208	148	178	179	202	247			
75	153		50	119	69	66	111			232		
105	76		-25	24	-46	-2	-58	54	137			

TABLE 3.- STRESSES AROUND CUTOUT OF 50° BY 1 BAY ON TENSION SIDE OF CYLINDER LOADED BY SHEAR

FORCE OF 2,000 POUNDS AT TIP (ACTUAL APPLIED LOAD, 5,000 POUNDS) - Continued

(c) Shear stresses, psi

Distance from center line of cutout, in.													
	36	30	24	18	12	6	0	6	12	18	24		
	----- 0 -----						49 ----- 15 -----						
	132		-61		-324	-190			550	690			
15						-975			1,889	1,215			
	316		203		-3	132	244	305	503	523	826		
					499	508	667	577	405	525	461		
45	559		595		784	717	773	649	615	459	427	675 688	
					893	855	816	755	700	535			
	814		872		951	925	859	799	776	633	570	737	
75						929	875	832	821	722	666		
	906		919		882	822	806	847	806	829	808	822	
105													
						717		747	719	780	798		
135			544			519		562	531				
						247							
165								191	371				

TABLE 3.- STRESSES AROUND CUTOUT OF 50° BY 1 BAY ON TENSION SIDE OF CYLINDER LOADED BY SHEAR

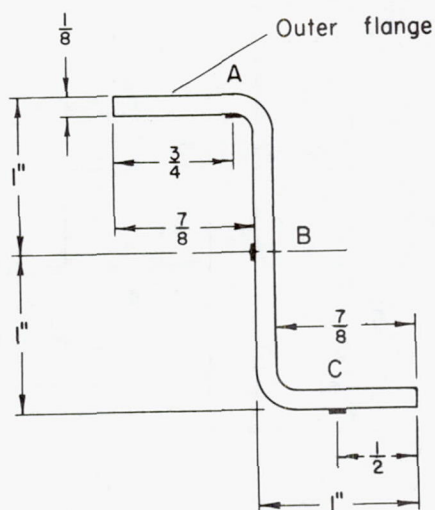
FORCE OF 2,000 POUNDS AT TIP (ACTUAL APPLIED LOAD, 5,000 POUNDS) - Continued

(d) Shear stresses due to cutout only

Distance from center line of cutout, in.																
	36	30	24	18	12	6	0	6	12	18	24					
	0												49	15		
15	-11		-204		-567	-333				407	547					
					-1,257					1,607	933					
	-96		-209		-415	-280	-168	-107	91	111	414					
45					-31	-22	-137	47	-125	-5	-69					
	-73		-37		152	85	-141	17	-17	-173	-185	43	56			
					179	141	102	41	-14	-179						
75	40		98		177	151	85	25	2	-141		-204	-37			
					117	63	20	9	-90		-146					
105	94		107		70	10	-6	35	-6	17		-4	20			
						-3		33	5	66		84				
135			14					32	1							
165								48	128							

TABLE 3.- STRESSES AROUND CUTOUT OF 50° BY 1 BAY ON TENSION SIDE
OF CYLINDER LOADED BY SHEAR FORCE OF 2,000 POUNDS AT
TIP (ACTUAL APPLIED LOAD, 5,000 POUNDS) - Concluded

(e) Ring stresses, psi



θ , deg	Ring 1			Ring 2		
	A	B	C	A	B	C
5	63	-407	-456	-4	-636	-689
15	63	---	-358	159	-352	-475
25	-121	-229	-68	-44	-212	0
35	-163	62	150	-174	67	263
45	-155	---	222	-221	168	343
55	-191	123	258	-274	184	401
65	-221	102	254	-282	131	343
75	-191	---	199	-248	106	246
85	-138	38	153	-172	40	117
95	-134	-15	87	-76	-4	40

TABLE 4.- STRESSES AROUND CUTOOUT OF 70° BY 1 BAY ON TENSION SIDE OF CYLINDER LOADED BY SHEAR
FORCE OF 2,000 POUNDS AT TIP (ACTUAL APPLIED LOAD, 4,400 POUNDS)

(a) Stringer stresses, psi

Distance from center line of cutout, in.												
	30	24	18	12	6	0	6	12	18	24	30	
15		280		67	0		0	424		1,431		
		460		111	0		0	453		1,623		
		595		491	0		0	1,012		1,831		
45		812		1,869	3,257	4,466	4,807	2,905		1,918		
		975		1,843	2,534	2,842	3,004	2,751		1,831		
		973		1,607	1,862	1,927	2,103	2,023		1,831		
75		848		1,178	1,269	1,224	1,404	1,503	1,515	1,542		
		665		843	780	761	843	934		1,132		
		173		-15	53	-91	-81	-154	72	120		
105												

TABLE 4.- STRESSES AROUND CUTOUT OF 70° BY 1 BAY ON TENSION SIDE OF CYLINDER LOADED BY SHEAR

FORCE OF 2,000 POUNDS AT TIP (ACTUAL APPLIED LOAD, 4,400 POUNDS) - Continued

(b) Stringer stresses due to cutout only, psi

Distance from center line of cutout, in.											
	30	24	18	12	6	0	6	12	18	24	30
15		-857		-1,394	-1,623		-1,947	-1,685		-1,002	
		-647		-1,312	-1,580		-1,896	-1,600		-746	
		-448		-849	-1,489		-1,786	-923		-401	
45		-135		652	1,906	2,980	3,186	1,149		-108	
		152		786	1,360	1,551	1,595	1,225		71	
		300		742	902	871	951	775		391	
75		345		532	551	435	543	571	511	466	
		347		435	327	262	299	345		452	
105		249		83	162	28	49	-13	224	283	

TABLE 4.- STRESSES AROUND CUTOUT OF 70° BY 1 BAY ON TENSION SIDE OF CYLINDER LOADED BY SHEAR

FORCE OF 2,000 POUNDS AT TIP (ACTUAL APPLIED LOAD, 4,400 POUNDS) - Continued

(c) Shear stresses, psi

		Distance from center line of cutout, in.											
		36	30	24	18	12	6	0	6	12	18	24	
15							-37			45	6		
	51			-64		-142	-100			426	492		
							-242			938	1,092		
	228			70		-559	-1,040			2,447	1,683		
45						118	257	391	590	764	496	863	
	483			477		695	726	946	726	560	361	391	783 784
						1,020	968	990	854	708	363		
75	740			889		1,093	992	964	925	803	545		406 694
						1,044	955	955	848	580		543	
105	966			946		946	889	805	843	833	807		726 751
						704		734	712	814		796	
135													
				556			504		573	494			
165						258							
								185	187				

θ,
deg

TABLE 4.- STRESSES AROUND CUTOUT OF 70° BY 1 BAY ON TENSION SIDE OF CYLINDER LOADED BY SHEAR

FORCE OF 2,000 POUNDS AT TIP (ACTUAL APPLIED LOAD, 4,400 POUNDS) - Continued

(d) Shear stresses due to cutout only

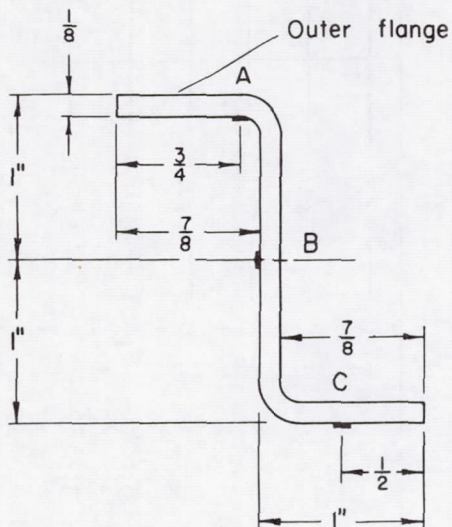
		Distance from center line of cutout, in.											
		36	30	24	18	12	6	0	6	12	18	24	
15							-37			45	6		
		-92		-207		-285	-243			283	349		
							-524			656	810		
		-184		-342		-971	-1,452			2,035	1,271		
45						-412	-273	-139	60	234	-34	333	
		-149		-155		63	94	114	94	-72	-271	-241	151 152
						306	254	176	142	-6	-351		
75		-34		115		319	218	190	151	29	-219	-368	-80
							232	143	143	36	-232	-269	
105		154		134		134	77	-7	31	21	-5	-86	-61
							-10		20	-2	100	82	
135													
				26			-26		43	-36			
165							-24						
								42	44				

TABLE 4.- STRESSES AROUND CUTOUT OF 70° BY 1 BAY ON TENSION SIDE

OF CYLINDER LOADED BY SHEAR FORCE OF 2,000 POUNDS AT

TIP (ACTUAL APPLIED LOAD, 4,400 POUNDS) - Concluded

(e) Ring stresses, psi



θ , deg	Ring 1			Ring 2		
	A	B	C	A	B	C
5	313	-523	-696	255	-1,036	-1,229
15	226	---	-583	265	-747	-1,048
25	156	-207	-328	315	-278	-499
35	-193	-147	67	-265	-10	308
45	-260	---	328	-374	308	590
55	-265	219	434	-458	374	701
65	-364	275	537	-534	349	720
75	-357	---	405	-520	197	506
85	-280	183	352	-434	96	294
95	-253	114	248	-258	34	125

TABLE 5.- STRESSES AROUND CUTOUT OF 90° BY 1 BAY ON TENSION SIDE OF CYLINDER LOADED BY SHEAR
FORCE OF 2,000 POUNDS AT TIP (ACTUAL APPLIED LOAD, 3,600 POUNDS)

(a) Stringer stresses, psi

Distance from center line of cutout, in.												
	30	24	18	12	6	0	6	12	18	24	30	
15		44		-18	0		0	294		1,060		
		159		9	0		0	318		1,231		
		374		82	0		0	418		1,508		
		686		568	0		0	1,125		1,826		
45		910		2,091	3,901	5,607	6,004	3,439		1,943		
		1,060		2,241	2,704	3,316	3,386	2,956		2,055		
		1,057		1,685	1,973	1,932	2,167	2,061	1,958	1,885		
75		877		1,178	1,207	1,066	1,178	1,266		1,407		
105		342		59	194	-41	6	-165	224	294		

TABLE 5.- STRESSES AROUND CUTOUT OF 90° BY 1 BAY ON TENSION SIDE OF CYLINDER LOADED BY SHEAR
FORCE OF 2,000 POUNDS AT TIP (ACTUAL APPLIED LOAD, 3,600 POUNDS) - Continued

(b) Stringer stresses due to cutout only, psi

Distance from center line of cutout, in.												
	30	24	18	12	6	0	6	12	18	24	30	
15		-1,093		-1,479	-1,623		-1,947	-1,815		-1,373		
		-948		-1,414	-1,580		-1,896	-1,735		-1,138		
		-669		-1,258	-1,489		-1,786	-1,517		-724		
		-261		-649	-1,351		-1,621	-631		-200		
45		87		1,034	2,727	4,316	4,595	1,913		183		
		387		1,376	1,744	2,260	2,234	1,708		615		
		554		1,039	1,255	1,143	1,306	1,129	954	809		
75		559		770	754	567	634	677		727		
105		418		157	303	78	136	-24	376	457		

TABLE 5.- STRESSES AROUND CUTOUT OF 90° BY 1 BAY ON TENSION SIDE OF CYLINDER LOADED BY SHEAR

FORCE OF 2,000 POUNDS AT TIP (ACTUAL APPLIED, 3,600 POUNDS) - Continued

(c) Shear stresses, psi

Distance from center line of cutout, in.												
	36	30	24	18	12	6	0	6	12	18	24	
15						-46			85	-5		
	23		-76		-27	-48			381	334		
						-86			725	762		
	117		-42		-380	-245			1,250	1,361		
45						-617	-1,216		2,987	1,921		
	366		287		240	422	563	664	1,103	351	848	1,046 1,003
					941	968	1,174	1,042	710	177		
	737		826		1,177	1,169	1,151	1,058	861	288	183	648
75						1,214	1,060	989	925	375	291	
	1,005		1,074		1,069	1,014	824	845	817	650	616	625
105												
						744		687	714	746	760	
135			586			501		522	492			
165						206						
								179	147			

TABLE 5.- STRESSES AROUND CUTOUT OF 90° BY 1 BAY ON TENSION SIDE OF CYLINDER LOADED BY SHEAR

FORCE OF 2,000 POUNDS AT TIP (ACTUAL APPLIED LOAD, 3,600 POUNDS) - Continued

(d) Shear stresses due to cutout only

		Distance from center line of cutout, in.											
		36	30	24	18	12	6	0	6	12	18	24	
15							-46			85	-5		
		-120		-219		-170	-191			238	191		
							-368			443	480		
		-295		-454		-792	-657			838	949		
45						-1,147	-1,746			2,457	1,291		
		-266		-345		-392	-210	-69	32	471	-281	116	414 371
						227	254	460	328	-4	-537		
		-37		52		403	395	377	284	87	-486	-591	-126
75						402	248	177	113	-437	-521		
		193		262		257	202	12	33	5	-162	-196	-187
105						30		-27	0	32		46	
135													
				56		-29		-8	-38				
165						-76							
								36	4				

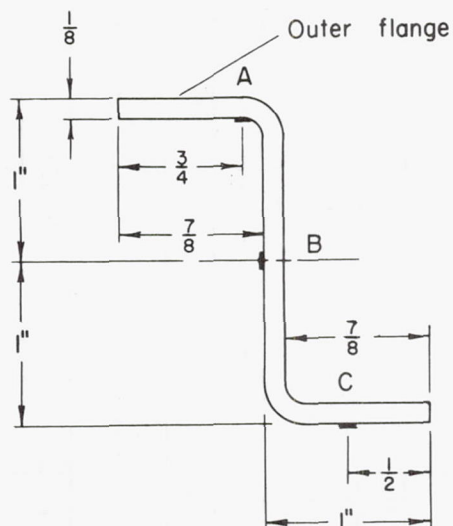
θ,
deg

TABLE 5.- STRESSES AROUND CUTOUT OF 90° BY 1 BAY ON TENSION SIDE

OF CYLINDER LOADED BY SHEAR FORCE OF 2,000 POUNDS AT

TIP (ACTUAL APPLIED LOAD, 3,600 POUNDS) - Concluded

(e) Ring stresses, psi



θ , deg	Ring 1			Ring 2		
	A	B	C	A	B	C
5	598	-648	-866	666	-1,346	-1,767
15	418	---	-727	539	-1,031	-1,440
25	262	-336	-530	289	-580	-801
35	41	-118	-236	224	144	-29
45	-392	---	298	-607	453	887
55	-444	241	562	-616	733	1,260
65	-518	406	733	-751	780	1,417
75	-507	---	698	-833	589	1,116
85	-416	383	712	-727	416	780
95	-350	268	527	-512	186	442

BLE 6.- STRESSES AROUND CUTOOUT OF 130° BY 1 BAY ON TENSION SIDE OF CYLINDER LOADED BY SHEAR

FORCE OF 2,000 POUNDS AT TIP (ACTUAL APPLIED LOAD, 2,200 POUNDS)

(a) Stringer stresses, psi

Distance from center line of cutout, in.

	Distance from center line of cutout, in.										θ, deg
	30	24	18	12	6	0	6	12	18	24	30
15	-202			-140	0		0	48		529	
	-158			-115	0		0	193		626	
	63			-38	0		0	203		915	
45	299			64	0		0	346		1,253	
	722			236	0		0	578		1,773	
	1,190			993	0		0	1,725		2,313	
75	1,478			3,168	5,968	8,190	9,568	5,155	3,041	2,518	
	1,732			3,245	4,091	4,254	4,700	4,064		2,455	
105	1,155			1,204	1,309	925	1,175		1,406	1,356	

TABLE 6.- STRESSES AROUND CUTOUT OF 130° BY 1 BAY ON TENSION SIDE OF CYLINDER LOADED BY SHEAR

FORCE OF 2,000 POUNDS AT TIP (ACTUAL APPLIED LOAD, 2,200 POUNDS) - Continued

(b) Stringer stresses due to cutout only, psi

		Distance from center line of cutout, in.										
		30	24	18	12	6	0	6	12	18	24	30
15	θ , deg	-1,339			-1,601	-1,623		-1,947	-2,061		-1,904	
		-1,265			-1,538	-1,580		-1,896	-1,860		-1,743	
		-980			-1,378	-1,489		-1,786	-1,732		-1,317	
		-648			-1,153	-1,351		-1,621	-1,410		-773	
45		-101			-821	-1,174		-1,409	-948		13	
517				128	-960		-1,152	477		873		
975				2,522	5,250	7,401	8,707	4,223	2,037	1,442		
75		1,414			2,837	3,638	3,755	4,156	3,475		1,775	
		1,231			1,302	1,418	1,044	1,305		1,558	1,519	
105												

TABLE 6.- STRESSES AROUND CUTOUT OF 130° BY 1 BAY ON TENSION SIDE OF CYLINDER LOADED BY SHEAR

FORCE OF 2,000 POUNDS AT TIP (ACTUAL APPLIED LOAD, 2,200 POUNDS) - Continued

(c) Shear stresses, psi

		Distance from center line of cutout, in.											
		36	30	24	18	12	6	0	6	12	18	24	
θ, deg		-7				75				0			
		-97	-58		134	68				257	122		
15						130				470	300		
		-101	-84		174	15				751	582		
					-21	23				1,084	1,082		
45		56	-32		-393	-204				1,732	1,896	1,566	1,435
					-787	-1,738				4,302			
		506	420		315	661	1,019	1,126		-86	932	1,103	
75						1,465	1,812	1,592	1,105	-371	-15		
		1,053	1,236		1,611	1,500	1,185	1,135	944	86	64	262	
105						1,086		655	715	506	596		
135			805			566		461	401				
						184							
165								131	101				

TABLE 6.- STRESSES AROUND CUTOUT OF 130° BY 1 BAY ON TENSION SIDE OF CYLINDER LOADED BY SHEAR

FORCE OF 2,000 POUNDS AT TIP (ACTUAL APPLIED LOAD, 2,200 POUNDS) - Continued

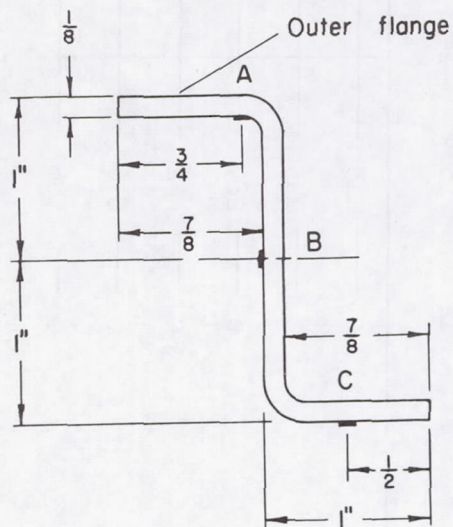
(d) Shear stresses due to cutout only, psi

Distance from center line of cutout, in.													
	36	30	24	18	12	6	0	6	12	18	24		
						-7		75	0				
15	-240		-201		-9	-75				114	-21		
						-152				188	18		
	-513		-496		-238	-397				339	170		
45					-551	-507				554	552		
	-576		-664		-1,025	-836				1,100	1,264	934	803
					-1,501	-2,452				3,588			
75	-268		-354		-459	-113	245	352		-860	158	329	
						653	1,000	780	293	-1,183	-827		
105	241		424		799	688	373	323	132	-726	-748	-550	
						374		-59	1	-208	-118		
135													
			275			36		-69	-129				
165						-98							
								-12	-42				

 θ ,
deg

TABLE 6.- STRESSES AROUND CUTOUT OF 130° BY 1 BAY ON TENSION SIDE
OF CYLINDER LOADED BY SHEAR FORCE OF 2,000 POUNDS AT
TIP (ACTUAL APPLIED LOAD, 2,200 POUNDS) - Concluded

(e) Ring stresses, psi



θ , deg	Ring 1			Ring 2		
	A	B	C	A	B	C
5	1,026	-665	-1,253	1,749	-1,836	-3,025
15	885	---	-1,098	1,460	-1,696	-2,554
25	691	-545	-920	993	-1,243	-1,816
35	260	-434	-593	184	-505	-698
45	-102	---	-58	-434	318	482
55	-693	164	289	-616	1,345	1,615
65	-1,133	265	1,075	-1,898	1,489	3,035
75	-1,113	---	1,484	-1,768	1,720	3,016
85	-1,012	901	1,609	-1,513	1,513	2,625
95	-962	843	1,764	-1,494	993	1,869

TABLE 7.- STRESSES AROUND CUTOUT OF 130° BY 2 BAYS ON TENSION SIDE OF CYLINDER LOADED BY SHEAR
FORCE OF 2,000 POUNDS AT TIP (ACTUAL APPLIED LOAD, 2,200 POUNDS)

(a) Stringer stresses, psi

Distance from center line of cutout, in.

θ , deg	Distance from center line of cutout, in.										
	24	18	12	6	0	6	12	18	24	30	36
15	-38	0					0	115		578	
	-53	0					0	193		665	
	0	0					0	289		838	
	43	0					0	472		1,291	
45	178	0					0	616		1,802	
	655	0					0	1,667		2,303	
	2,120	3,517	5,006	6,456	7,931	(8,480) 9,530	5,011	3,035	2,515		
75	2,303		3,469	4,009	4,385	4,799	4,053		2,582		
105	1,368		1,108	1,416	867	1,108		1,349	1,368		

TABLE 7.- STRESSES AROUND CUTOUT OF 130° BY 2 BAYS ON TENSION SIDE OF CYLINDER LOADED BY SHEAR
FORCE OF 2,000 POUNDS AT TIP (ACTUAL APPLIED LOAD, 2,200 POUNDS) - Continued

(b) Stringer stresses due to cutout only, psi

		Distance from center line of cutout, in.									
		24	18	12	6	0	6	12	18	24	30
15	θ, deg	-1,175	-1,299					-1,947	-1,994		-1,855
		-1,160	-1,265					-1,896	-1,860		-1,704
		-1,043	-1,192					-1,786	-1,646		-1,394
		-904	-1,082					-1,621	-1,284		-735
45		-645	-940					-1,409	-910		42
		-18	-769					-1,152	419		863
		1,617	2,943	4,360	5,738	7,142	(7,619) 8,669	4,079	2,031	1,439	
75		1,985		3,061	3,556	3,886	4,255	3,464		1,902	
105		1,444		1,206	1,525	986	1,238		1,501	1,531	

TABLE 7.- STRESSES AROUND CUTOUT OF 130° BY 2 BAYS ON TENSION SIDE OF CYLINDER LOADED BY SHEAR

FORCE OF 2,000 POUNDS AT TIP (ACTUAL APPLIED LOAD, 2,200 POUNDS) - Continued

(c) Shear stresses, psi

		Distance from center line of cutout, in.											
		30	24	18	12	6	0	6	12	18	24	30	
θ, deg												90	4
												243	112
15	-75		142									476	296
	-21		223									712	530
45	-19		-191									1,038	1,011
												1,657	1,807
												4,078	
75	390		234		794	946	948	1,124	1,813	105	940	1,144	
						1,206	1,659	1,547	1,079	-243	22		
105	1,161		1,435		1,225	1,154	1,274	1,266	1,067	75	52	251	
						790		655	715	464	603		
135			809			569		382	371				
165						292							
								90	97				

TABLE 7.- STRESSES AROUND CUTOUT OF 130° BY 2 BAYS ON TENSION SIDE OF CYLINDER LOADED BY SHEAR

FORCE OF 2,000 POUNDS AT TIP (ACTUAL APPLIED LOAD, 2,200 POUNDS) - Continued

(d) Shear stresses due to cutout only

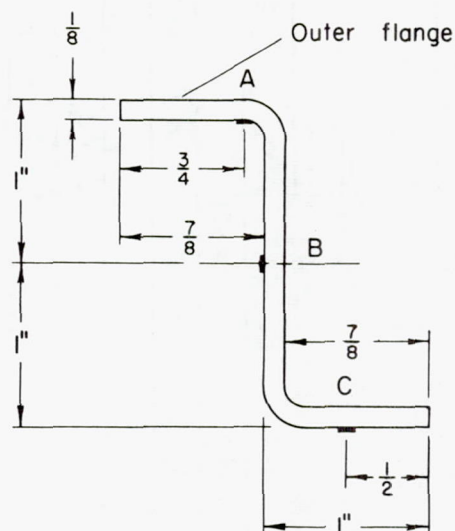
Distance from center line of cutout, in.														
	30	24	18	12	6	0	6	12	18	24	30			
15	-218		-1									90	4	
												100	-31	
												194	14	
45	-433		-189									300	118	
												508	481	
	-651		-823									1,025	1,175	911 792
75												3,364		
	-384		-540		20	172	174	350	1,039	-669	166	370		
						394	847	735	267	-1,055	-790			
105														
	349		623		413	342	462	454	255	-737	-750	-561		
135														
						76		-59	1	-250	-111			
165			-179			39		-148	-159					
						10								
								-53	-46					

TABLE 7.- STRESSES AROUND CUTOUT OF 130° BY 2 BAYS ON TENSION SIDE

OF CYLINDER LOADED BY SHEAR FORCE OF 2,000 POUNDS AT

TIP (ACTUAL APPLIED LOAD, 2,200 POUNDS) - Concluded

(e) Ring stresses, psi



θ , deg	Ring 1			Ring 2		
	A	B	C	A	B	C
5				2,072	-1,973	-3,218
15				1,696	-1,647	-2,804
25				1,176	-1,387	-1,936
35				269	-597	-771
45				-458	280	419
55				-781	1,296	1,691
65				-1,879	1,335	3,180
75	-530	---	304	-1,894	1,744	3,276
85	-313	92	371	-1,855	1,537	2,780
95	-197	187	419	-1,638	1,133	2,125

TABLE 8.- STRESSES AROUND SIDE CUTOUT OF 30° BY 1 BAY IN CYLINDER LOADED BY SHEAR

FORCE OF 2,000 POUNDS AT TIP (ACTUAL APPLIED LOAD, 7,200 POUNDS)

(a) Stringer stresses, psi

Distance from center line of cutout, in.												
	30	24	18	12	6	0	6	12	18	24	30	
15		118		203	0		0	-103		88		
		337		908	1,786	474	-941	-177		389		
		554		856	935	736	502	509		810		
45		730		845	872	972	1,076	1,148		1,207		
		817		932	1,028	1,148	1,393	1,440		1,513		
		919		1,067	1,182	1,399	1,690	1,737		1,943		
75		983		1,175	1,366	1,611	1,849	1,947	2,092	2,120		
		1,001		1,251	1,487	1,693	1,855	2,064		2,341		
105		1,057		1,590		1,752	2,061		2,385	2,426		

TABLE 8.- STRESSES AROUND SIDE CUTOUT OF 30° BY 1 BAY IN CYLINDER LOADED BY SHEAR

FORCE OF 2,000 POUNDS AT TIP (ACTUAL APPLIED LOAD, 7,200 POUNDS) - Continued

(b) Stringer stresses due to cutout only, psi

Distance from center line of cutout, in.												
	30	24	18	12	6	0	6	12	18	24	30	
15		42		105	-108		-130	-244		-75		
		105		558	1,397	46	-1,408	-682		-194		
		93		264	278	13	-287	-345		-176		
		95		30	-34	-24	-10	-29		-151		
45		27		-82	-99	-91	41	-24		-176		
		-1		-115	-131	-45	115	31		-25		
		-40		-139	-94	5	98	50	49	-68		
75		-93		-155	-75	-25	-19	34		0		
		-80		129		-33	114		114	-7		
105												

TABLE 8.- STRESSES AROUND SIDE CUTOUT OF 30° BY 1 BAY IN CYLINDER LOADED BY SHEAR

FORCE OF 2,000 POUNDS AT TIP (ACTUAL APPLIED LOAD, 7,200 POUNDS) - Continued

(c) Shear stresses, psi

Distance from center line of cutout, in.														
	36	30	24	18	12	6	0	6	12	18	24			
15						-973			-1,197	-1,184				
	-849		-890		-1,071	-1,328			-1,329	-1,081				
					-450	-1,057	-1,079	-1,070	-454	-671				
	-719		-698		-510	-532	-1,056	-1,282	-1,124	-528	-518			
45					-510	-566	-961	-1,095	-1,025	-551	-520			
	-540		-488		-494	-509	-798	-867	-785	-492	-519	-432	-466	
					-423	-429	-544	-582	-566	-413				
	-279		-283		-388	-344	-300	-341	-333	-330	-433	-224		
75					-175	-93	-118	-98	-191	-264				
	150		157		164	109	293	220	257	167	66	-108		
105														
						384		500	474	483	422			
135														
			637			633		651	666					
165						788								
								816	784					

TABLE 8.- STRESSES AROUND SIDE CUTOUT OF 30° BY 1 BAY IN CYLINDER LOADED BY SHEAR

FORCE OF 2,000 POUNDS AT TIP (ACTUAL APPLIED LOAD, 7,200 POUNDS) - Continued

(d) Shear stresses due to cutout only, psi

		Distance from center line of cutout, in.											
		36	30	24	18	12	6	0	6	12	18	24	
15							-148			-372	-359		
		-37		-78		-259	-516			-517	-269		
						324	-283	-305	-296	320	103		
		-5		16		204	182	-342	-568	-410	186	196	
45						122	66	-329	-463	-393	81	112	
		-10		42		36	21	-268	-337	-255	38	11	98 64
						-11	-17	-132	-170	-154	-1		
		3		-1		-106	-62	-18	-59	-51	-48	-151	58
75						-32	50	25	45	-48		-121	
		7		14		21	-34	150	77	114	24	-77	251
105						-28		88	62	71		10	
135				5			1	19	34				
165						14							
								4	-28				

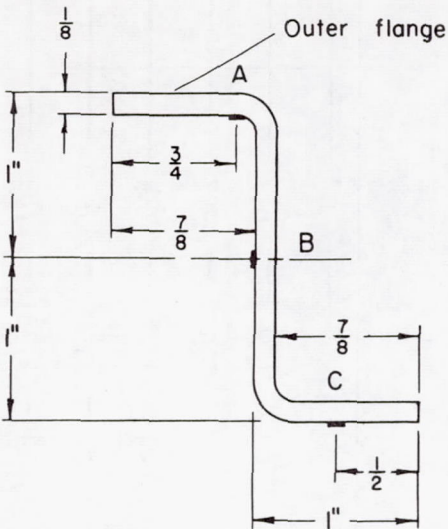
θ,
deg

TABLE 8.- STRESSES AROUND SIDE CUTOUT OF 30° BY 1 BAY IN CYLINDER

LOADED BY SHEAR FORCE OF 2,000 POUNDS AT TIP (ACTUAL

APPLIED LOAD, 7,200 POUNDS) - Concluded

(e) Ring stresses, psi



θ , deg	Ring 1			Ring 2		
	A	B	C	A	B	C
95	-53	848	965	573	339	-360
85	0	1,007	1,028	605	244	-392
75	212	---	954	466	244	-339
65	625	901	625	127	222	-74
55	816	424	85	-212	530	360
45	944	---	-551	-297	854	806
35	742	-932	-1,034	-117	1,369	1,282
25	371	-1,389	-1,632	424	1,696	1,441
15	---	---	-1,642	509	1,272	1,272
5	---	-815	-742	816	456	42
5	636	519	350	0	-1,060	-1,113
15	350	---	1,230	53	-1,908	-2,109
25	-148	1,272	1,358	0	-2,067	-1,961
35	-742	848	1,071	148	-1,696	-1,590
45	-944	---	626	10	-1,007	-764
55	-848	-329	106	0	-392	0
65	-647	-657	-276	-636	0	530
75	-540	-752	-520	-952	201	848
85	-435	-785	-520	-1,166	297	1,007
95	-318	-710	-530	-1,230	0	901

TABLE 9.- STRESSES AROUND SIDE CUTOUT OF 50° BY 1 BAY IN CYLINDER LOADED BY SHEAR

FORCE OF 2,000 POUNDS AT TIP (ACTUAL APPLIED LOAD, 7,200 POUNDS)

(a) Stringer stresses, psi

Distance from center line of cutout, in.												
	30	24	18	12	6	0	6	12	18	24	30	
15		124		91	0		0	0		44		
		433		484	0		0	-12		294		
		603		1,343	2,792	878	-1,178	-77		661		
		780		1,101	1,199	1,022	788	794		1,072		
45		831		922	989	1,151	1,400	1,475		1,428		
		874		958	1,006	1,414	1,731	1,825		1,875		
		911		1,034	1,134	1,502	1,870	2,017	2,035	2,179		
75		965		1,172	1,314	1,600	1,958	2,086		2,356		
105		967		1,508		1,686	2,036		2,378	2,453		

TABLE 9.- STRESSES AROUND SIDE CUTOUT OF 50° BY 1 BAY IN CYLINDER LOADED BY SHEAR

FORCE OF 2,000 POUNDS AT TIP (ACTUAL APPLIED LOAD, 7,200 POUNDS) - Continued

(b) Stringer stresses due to cutout only, psi

Distance from center line of cutout, in.												
	30	24	18	12	6	0	6	12	18	24	30	
15	48			-7	-108		-130	-141		-119		
	161			134	-389		-467	-517		-289		
	142			751	2,135	155	-1,967	-931		-325		
45	145			286	293	26	-298	-383		-286		
	41			-92	-138	88	48	11		-261		
	46			-224	-307	-30	156	119		-93		
75	-112			-280	-326	-104	119	120	-8	-9		
	-129			-234	-248	-118	84	56		15		
105	-70			47		-99	89		-107	20		

 θ ,
deg

TABLE 9.- STRESSES AROUND SIDE CUTOUT OF 50° BY 1 BAY IN CYLINDER LOADED BY SHEAR

FORCE OF 2,000 POUNDS AT TIP (ACTUAL APPLIED LOAD, 7,200 POUNDS) - Continued

(c) Shear stresses, psi

Distance from center line of cutout, in.													
	36	30	24	18	12	6	0	6	12	18	24		
15						-787			-1,138	-1,162			
	-851		-925		-958	-889			-1,154	-1,118			
						-1,527			-1,267	-950			
	-738		-682		-524	-218	-1,372	-1,532	-1,410	-120	-403		
45					-372	-389	-1,321	-1,556	-1,358	-325	-317		
	-512		-437		-402	-407	-1,111	-1,220	-1,080	-398	-391	-386	-402
					-437	-389	-756	-787	-766	-373			
	-249		-260		-417	-331	-393	-434	-442	-304		-461	-212
75						-195	-100	-132	-58	-232		-334	
	141		114		130	101	351	288	287	119		23	73
105													
						348		550	514			391	
135													
			640			732		682	651	455			
165						795							
								808	810				

θ,
deg

TABLE 9.- STRESSES AROUND SIDE CUTOUT OF 50° BY 1 BAY IN CYLINDER LOADED BY SHEAR

FORCE OF 2,000 POUNDS AT TIP (ACTUAL APPLIED LOAD, 7,200 POUNDS) - Continued

(d) Shear stresses due to cutout only, psi

		Distance from center line of cutout, in.											
		36	30	24	18	12	6	0	6	12	18	24	
15							38			-313	-337		
		-39		-113		-146	-77			-342	-306		
							-753			-493	-176		
45		-24		32		190	496	-658	-818	-696	594	311	
						260	243	-689	-924	-726	307	315	
	18			93		128	123	-581	-690	-520	132	139	144 128
75						-25	23	-344	-375	-354	39		
	33			22		-135	-49	-111	-152	-160	-22		-179 70
							-52	43	11	85	-89		-191
105		-2		-29		-13	-42	208	145	144	-24		-120 -70
							-64		138	102	-177		-21
135													
				8			100		50	19			
165							21						
								-4	-2				

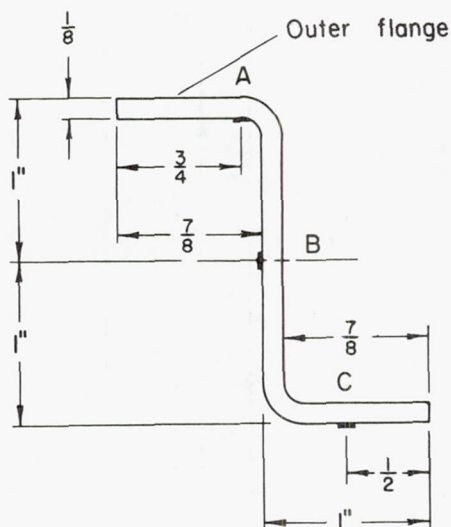
θ,
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TABLE 9.- STRESSES AROUND SIDE CUTOOUT OF 50° BY 1 BAY IN CYLINDER

LOADED BY SHEAR FORCE OF 2,000 POUNDS AT TIP (ACTUAL

APPLIED LOAD, 7,200 POUNDS) - Concluded

(e) Ring stresses, psi



θ , deg	Ring 1			Ring 2		
	A	B	C	A	B	C
95	-498	1,325	1,760	1,177	-286	-1,208
85	-212	1,654	1,802	912	-541	-1,272
75	286	1,208	1,484	413	-488	-1,071
65	985	1,198	763	-191	-53	-424
55	1,400	180	-339	-721	742	636
45	1,484	-572	-1,516	-742	1,802	1,728
35	1,113	-2,385	-2,438	-371	2,809	2,851
25	159	-2,470	-3,286	106	2,968	3,339
15	0	-1,548	-2,120	625	2,385	2,088
5	456	-1,028	-986	488	753	403
5	254	604	551	572	-1,283	-1,643
15	435	1,749	1,813	32	-2,957	-3,074
25	-53	2,300	3,021	371	-3,244	-3,869
35	-965	2,109	2,533	392	-3,106	-3,201
45	-1,357	-74	1,579	530	-1,875	-1,749
55	-1,399	-106	583	265	-625	-339
65	-1,060	-922	-445	-403	244	742
75	-615	-1,166	-996	-975	636	1,484
85	-233	-1,442	-1,261	-1,304	742	1,770
95	74	-1,219	-996	-1,622	562	1,654

TABLE 10.- STRESSES AROUND SIDE CUTOUT OF 70° BY 1 BAY IN CYLINDER LOADED BY SHEAR

FORCE OF 2,000 POUNDS AT TIP (ACTUAL APPLIED LOAD, 5,600 POUNDS)

(a) Stringer stresses, psi

Distance from center line of cutout, in.												
	30	24	18	12	6	0	6	12	18	24	30	
15		99		41	0		0	15		34		
		413		204	0		0	19		223		
		641		668	0		0	45		477		
45		842		1,794	3,713	1,211	-1,305	-15		871		
		965		1,300	1,452	1,355	1,128	1,090		1,336		
		978		1,003	987	1,507	1,808	1,866		1,760		
75		927		933	1,022	1,722	2,110	2,240	2,035	2,158		
		946		1,098	1,222	1,703	2,195	2,385		2,441		
105		985		1,456		1,741	2,082		2,460	2,500		

θ,
deg

TABLE 10.- STRESSES AROUND SIDE CUTOUT OF 70° BY 1 BAY IN CYLINDER LOADED BY SHEAR

FORCE OF 2,000 POUNDS AT TIP (ACTUAL APPLIED LOAD, 5,600 POUNDS) - Continued

(b) Stringer stresses due to cutout only, psi

Distance from center line of cutout, in.												
	30	24	18	12	6	0	6	12	18	24	30	
15		23		-57	-108		-130	-126		-129		
		141		-156	-389		-467	-486		-360		
		180		76	-657		-789	-899		-509		
45		207		979	2,807	215	-2,391	-1,192		-487		
		175		286	325	116	-224	-374		-353		
		58		-179	-326	63	233	160		-208		
75		-96		-381	-438	116	359	343	-8	-30		
		-148		-308	-351	-15	221	355		100		
105		-152		-5		-44	135		189	67		

θ,
deg

TABLE 10.- STRESSES AROUND SIDE CUTOUT OF 70° BY 1 BAY IN CYLINDER LOADED BY SHEAR

FORCE OF 2,000 POUNDS AT TIP (ACTUAL APPLIED LOAD, 5,600 POUNDS) - Continued

(c) Shear stresses, psi

Distance from center line of cutout, in.													
	36	30	24	18	12	6	0	6	12	18	24		
15						-656			-1,168	-1,094			
	-872		-893		-712	-699			-1,086	-1,075			
						-869			-1,056	-1,027			
	-697		-696		-1,055	-1,726			-1,100	-686			
45					-390	54	-1,768	-1,970	-1,793	269	-115		
	-532		-422		-188	-162	-1,584	-1,980	-1,565	-100	-115	-259	-309
					-281	-274	-1,146	-1,414	-1,255	-238			
75	-241		-218		-374	-305	-674	-725	-741	-281	-456	-160	
					-212	-222	-212	-246	-253	-396			
105	129		93		72	44	438	374	371	78	-69	47	
						354		621	603	402	-347		
135													
			633			609		684	714				
165						792							
								762	731				

θ,
deg

TABLE 10.- STRESSES AROUND SIDE CUTOUT OF 70° BY 1 BAY IN CYLINDER LOADED BY SHEAR

FORCE OF 2,000 POUNDS AT TIP (ACTUAL APPLIED LOAD, 5,600 POUNDS) - Continued

(d) Shear stresses due to cutout only, psi

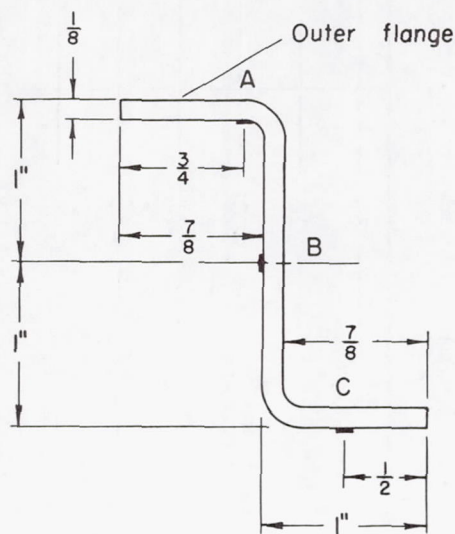
Distance from center line of cutout, in.													
	36	30	24	18	12	6	0	6	12	18	24		
15						169			-343	-269			
	-60		-81		100	113			-274	-263			
						-95			-282	-253			
	17		18		-341	-1,012			-386	28			
45					242	686	-1,136	-1,338	-1,161	901	517		
	-2		108		342	368	-1,054	-1,450	-1,035	430	415	271	221
					131	138	-734	-1,002	-843	174			
	41		64		-92	-23	-392	-443	-459	1	-174	122	
75						-69	-79	-69	-103	-110	-253		
	-14		-50		-71	-99	295	231	228	-65	-212	-96	
105													
						-58		209	191	-10	-759		
135													
			1			-23		52	82				
165						18							
								-50	-81				

TABLE 10.- STRESSES AROUND SIDE CUTOUT OF 70° BY 1 BAY IN CYLINDER

LOADED BY SHEAR FORCE OF 2,000 POUNDS AT TIP (ACTUAL

APPLIED LOAD, 5,600 POUNDS) - Concluded

(e) Ring stresses, psi



θ , deg	Ring 1			Ring 2		
	A	B	C	A	B	C
95	-551	1,473	2,173	1,272	-763	-1,887
85	-95	1,823	2,067	890	-1,028	-1,887
75	721	1,177	1,304	106	-594	-1,336
65	1,134	816	403	-636	74	-106
55	1,473	-413	-901	-1,039	1,399	1,484
45	1,251	-1,230	-2,311	-848	2,756	2,968
35	456	-2,555	-3,286	-912	3,392	4,240
25	647	-2,841	-3,180	-318	3,445	3,943
15	795	---	-2,120	-488	2,120	2,438
5	689	-700	-816	106	752	424
5	-371	477	742	827	-1,188	-1,654
15	-806	1,272	2,120	1,007	-2,756	-3,021
25	-392	2,841	2,809	678	-3,604	-4,240
35	-901	2,544	3,445	859	-3,551	-4,505
45	-1,166	---	2,438	647	-2,650	-2,756
55	-1,367	657	1,092	445	-1,113	-848
65	-1,145	-498	-265	0	276	773
75	-689	-1,166	-1,145	-636	1,007	1,665
85	-159	-1,516	-1,654	-1,177	1,219	2,226
95	371	-1,643	-1,579	-1,526	1,124	2,226

TABLE 11.- STRESSES AROUND SIDE CUTOUT OF 90° BY 1 BAY IN CYLINDER LOADED BY SHEAR

FORCE OF 2,000 POUNDS AT TIP (ACTUAL APPLIED LOAD, 4,200 POUNDS)

(a) Stringer stresses, psi

Distance from center line of cutout, in.												
	30	24	18	12	6	0	6	12	18	24	30	
15		83		55	0		0	35		40		
		346		150	0		0	10		136		
		598		328	0		0	-50		313		
		921		906	0		0	-131		590		
45		1,065		2,183	4,970	1,726	-1,651	-86		1,000		
		1,141		1,560	1,641	1,716	1,507	1,479		1,464		
		1,035		994	1,010	1,772	2,304	2,392	2,011	2,009		
75		1,000		969	1,045	1,777	2,473	2,706		2,448		
105		889		1,318		1,797	2,408		2,766	2,690		

TABLE 11.- STRESSES AROUND SIDE CUTOUT OF 90° BY 1 BAY IN CYLINDER LOADED BY SHEAR

FORCE OF 2,000 POUNDS AT TIP (ACTUAL APPLIED LOAD, 4,200 POUNDS) - Continued

(b) Stringer stresses due to cutout only, psi

Distance from center line of cutout, in.												
	30	24	18	12	6	0	6	12	18	24	30	
15	7			43	-108		-130	-106		-123		
	74			200	-389		-467	-495		-447		
	137			264	-657		-789	-904		-673		
45	286			91	-906		-1,086	-1,308		-768		
	275			1,169	-3,843	487	-3,003	-1,550		-689		
	221			378	-328	272	-68	-227		-504		
75	12			-320	450	166	553	495	-32	-179		
	-94			-437	517	59	599	676		107		
105	-248			-143		12	461		495	257		

θ,
deg

TABLE 11.- STRESSES AROUND SIDE CUTOUT OF 90° BY 1 BAY IN CYLINDER LOADED BY SHEAR

FORCE OF 2,000 POUNDS AT TIP (ACTUAL APPLIED LOAD, 4,200 POUNDS) - Continued

(c) Shear stresses, psi

		Distance from center line of cutout, in.											
		36	30	24	18	12	6	0	6	12	18	24	
15							-530			-1,124	-1,012		
		-916		-881		-579	-589			-1,097	-991		
							-671			-1,048	-981		
		-748		-783		-1,012	-952			-960	-852		
45						-1,232	-2,080			-963	-510		
		-510		-464		-240	389	-2,349	-2,609	-2,178	670	137	-203 -276
						-12	24	-1,874	-2,344	-1,972	97		
		-206		-194		-202	-173	-1,220	-1,466	-1,369	-165	-302	-58
75						-124	-563	-593	-614	-257	-420		
		-135		-61		-20	0	487	471	449	-41	-218	-18
105							288		765	783	332	-251	
135							604		767	828			
165							804						
								698	704				

TABLE 11.-- STRESSES AROUND SIDE CUTOUT OF 90° BY 1 BAY IN CYLINDER LOADED BY SHEAR
FORCE OF 2,000 POUNDS AT TIP (ACTUAL APPLIED LOAD, 4,200 POUNDS) - Continued

(d) Shear stresses due to cutout only, psi

		Distance from center line of cutout, in.											
		36	30	24	18	12	6	0	6	12	18	24	
15							295						
		-104		-69		-233	233				-299	-187	
							103				-285	-179	
		-34		-69		-298	-238				-274	-207	
45							-1,448				-246	-138	
											-331	122	
		20		-66		-290	919	-1,819	-2,079	-1,648	1,200	667	327
							436	-1,462	-1,932	-1,560	509		254
75		76		80		80	109	-938	-1,184	-1,087	117	-20	224
							19	-420	-450	-457	-114	-277	
105		8		-163		-163	-143	344	328	306	-184	-361	-161
							-124		353	371	-80	-663	
135													
				15		-28		137	196				
165							30						
								-114	108				

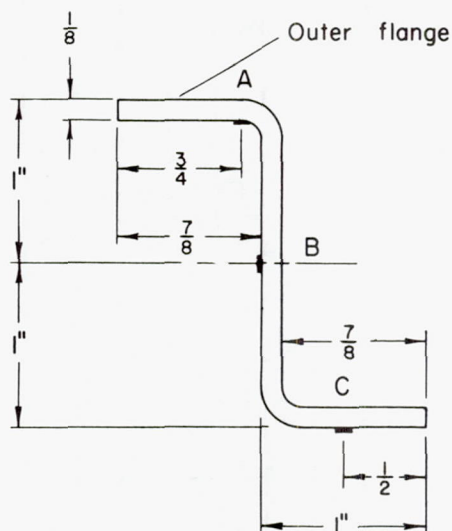
θ,
deg

TABLE 11.- STRESSES AROUND SIDE CUTOUT OF 90° BY 1 BAY IN CYLINDER

LOADED BY SHEAR FORCE OF 2,000 POUNDS AT TIP (ACTUAL

APPLIED LOAD, 4,200 POUNDS) - Concluded

(e) Ring stresses, psi



θ , deg	Ring 1			Ring 2		
	A	B	C	A	B	C
95	-445	1,643	2,438	1,230	-1,675	-2,438
85	132	1,802	2,003	604	-1,378	-2,120
75	848	859	1,124	-138	-678	-1,060
65	1,219	-32	-276	-583	636	477
55	1,293	-1,420	-1,728	-827	2,184	2,162
45	859	---	-3,286	-1,272	3,127	4,113
35	954	-2,512	-2,968	-1,166	3,604	4,452
25	1,495	-2,120	-2,809	-1,548	3,169	4,092
15	1,081	---	-1,802	-1,049	2,067	2,544
5	509	-413	-647	-233	625	668
5	-329	488	594	912	-848	-1,526
15	-1,177	731	2,014	1,516	-2,268	-3,201
25	-1,420	2,321	3,032	1,855	-3,286	-4,282
35	-710	2,915	3,032	1,272	-3,880	-4,653
45	-890	---	3,286	1,124	-3,244	-3,710
55	-986	1,463	1,802	498	-1,834	-1,696
65	-1,166	212	307	212	-138	53
75	-742	-943	-954	-424	742	1,410
85	-265	-1,590	-1,738	-880	1,431	2,396
95	371	-1,834	-1,940	-1,442	1,579	2,639

TABLE 12.- STRESSES AROUND SIDE CUTOUT OF 130° BY 1 BAY IN CYLINDER LOADED BY SHEAR
FORCE OF 2,000 POUNDS AT TIP (ACTUAL APPLIED LOAD, 2,800 POUNDS)

(a) Stringer stresses, psi

Distance from center line of cutout, in.												
	30	24	18	12	6	0	6	12	18	24	30	
15		64		34	0		0	0		0		
		276		124	0		0	-84		-68		
		484		212	0		0	-114		-53		
		734		321	0		0	-129		53		
45		984		553	0		0	-151		212		
		1,234		1,287	0		0	-273		583		
		1,306		2,989	(6,299) 8,236	2,264	(-2,658) -901	151	(772) 1,393	1,060		
75		1,090		1,628	1,885	2,059	1,991	2,042		1,787		
105		765		636		1,893	3,096	3,324	3,021	2,831		

TABLE 12.- STRESSES AROUND SIDE CUTOUT OF 130° BY 1 BAY IN CYLINDER LOADED BY SHEAR

FORCE OF 2,000 POUNDS AT TIP (ACTUAL APPLIED LOAD, 2,800 POUNDS) - Continued

(b) Stringer stresses due to cutout only, psi

Distance from center line of cutout, in.												
	30	24	18	12	6	0	6	12	18	24	30	
15		-12		-64	-108		-130	-141		-163		
		4		-226	-389		-467	-589		-651		
		23		-480	-657		-789	-968		-1,039		
		99		-494	-906		-1,086	-1,306		-1,305		
45		194		-461	-1,127		-1,352	-1,615		-1,477		
		314		105	-1,313		-1,575	-1,979		-1,385		
		283		1,675	(4,839) 6,776	658	(-4,409) -2,652	-1,746	(-1,271) -650	-1,128		
75		-4		222	323	341	117	12		-554		
105												
		-372		-825		108	1,149	1,215	750	398		

TABLE 12.- STRESSES AROUND SIDE CUTOUT OF 130° BY 1 BAY IN CYLINDER LOADED BY SHEAR

FORCE OF 2,000 POUNDS AT TIP (ACTUAL APPLIED LOAD, 2,800 POUNDS) - Continued

(c) Shear stresses, psi

Distance from center line of cutout, in.													
	36	30	24	18	12	6	0	6	12	18	24		
						-309			-956	-739			
15	-795		-597		-184	-362			-931	-716			
						-415			-902	-762			
	-721		-675		-527	-500			-837	-790			
45					-875	-724			-780	-828			
	-530		-653		-1,329	-1,205			-783	-692		-325	-331
					-1,368	-2,968			-743				
75	-240		-275		-50	1,083	-3,520	-3,626	-3,275	1,354		180	207
						468	-2,490	-3,193	-2,445	359		65	
105	171		88		-74	0	-12	-132	-177	-321		-559	-44
						197		1,177	1,009	-44		-156	
135													
			536			597		1,171	1,186				
						887							
165													
								736	739				

TABLE 12.- STRESSES AROUND SIDE CUTOUT OF 130° BY 1 BAY IN CYLINDER LOADED BY SHEAR

FORCE OF 2,000 POUNDS AT TIP (ACTUAL APPLIED LOAD, 2,800 POUNDS) - Continued

(d) Shear stresses due to cutout only, psi

Distance from center line of cutout, in.

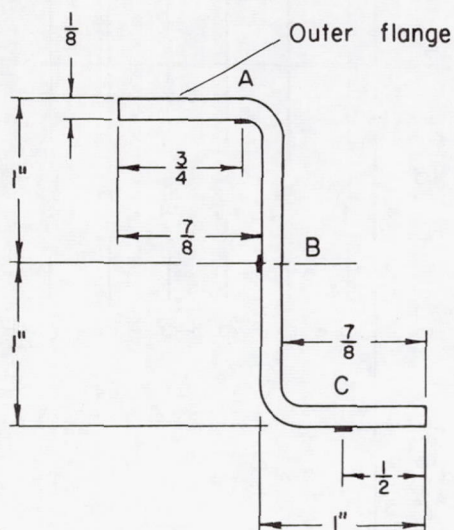
	36	30	24	18	12	6	0	6	12	18	24
15						516			-131	86	
	17		215		628	450			-119	96	
						359			-128	12	
	-7		39		187	214			-123	-76	
45					-243	-92			-148	-196	
	0		-123		-799	-675			-253	-162	205 199
					-956	-2,556			-331		
75	42		7		232	1,365	-3,238 -3,344 -2,993	1,636		462	489
					611		-2,347 -3,050 -2,302	502		208	
105	28		-55		-217	-143	-155 -175 -320	-464		-702	-187
						-215	765 597	-456		-568	
135											
			-96			-35	539 554				
165						113					
							-76 -73				

TABLE 12.- STRESSES AROUND SIDE CUTOUT OF 130° BY 1 BAY IN CYLINDER

LOADED BY SHEAR FORCE OF 2,000 POUNDS AT TIP (ACTUAL

APPLIED LOAD, 2,800 POUNDS) - Concluded

(e) Ring stresses, psi



θ , deg	Ring 1			Ring 2		
	A	B	C	A	B	C
95	-106	1,548	2,364	657	-1,664	-2,490
85	191	742	1,283	212	-498	-1,113
75	509	---	-265	-212	1,198	710
65	265	-1,590	-1,950	-1,092	2,406	3,140
55	625	-2,417	-2,480	-1,378	3,820	4,150
45	1,696	---	-2,798	-2,406	3,450	4,480
35	2,120	-1,410	-2,576	-2,714	2,870	4,450
25	1,781	-1,208	-2,184	-2,247	2,280	3,390
15	1,134	---	-1,399	-1,134	1,124	1,887
5	445	-392	-625	-21	186	191
5	-318	212	350	1,092	-901	-1,590
15	-1,124	---	1,208	1,908	-1,855	-3,190
25	-1,887	1,208	2,131	2,671	-2,544	-4,140
35	-2,131	1,696	2,650	2,756	-3,270	-4,800
45	-1,834	---	2,968	2,014	-3,340	-4,380
55	-647	2,406	2,682	869	-2,650	-3,160
65	-710	1,643	2,184	466	-1,484	-1,590
75	-541	---	731	-678	-371	106
85	-466	-445	-742	-721	1,007	2,099
95	0	-1,548	-1,696	-1,399	1,982	3,250

TABLE 13.- STRESSES AROUND SIDE CUTOUT OF 130° BY 2 BAYS IN CYLINDER LOADED BY SHEAR

FORCE OF 2,000 POUNDS AT TIP (ACTUAL APPLIED LOAD, 2,000 POUNDS)

(a) Stringer stresses, psi

Distance from center line of cutout, in.											
	24	18	12	6	0	6	12	18	24	30	36
15		21	0				0	-53		-83	
		129	0				0	-170		-318	
		244	0				0	-307		-339	
		371	0				0	-244		-392	
45		546	0				0	-551		-382	
		1,368	0				0	-689		0	
		3,610	9,026	(4,558) 6,519	(1,357) 3,440	-1,590	(-5,194) -2,258	-1,378	(117) 1,187	477	
75		1,601		1,484	1,473	1,357	562	816		1,155	
105				1,642		2,750	3,180		2,750	2,650	

TABLE 13.- STRESSES AROUND SIDE CUTOUT OF 130° BY 2 BAYS IN CYLINDER LOADED BY SHEAR

FORCE OF 2,000 POUNDS AT TIP (ACTUAL APPLIED LOAD, 2,000 POUNDS) - Continued

(b) Stringer stresses due to cutout only, psi

Distance from center line of cutout, in.												
	24	18	12	6	0	6	12	18	24	30	36	
15		-55	-87				-130	-194		-246		
		-143	-311				-467	-675		-901		
		-217	-526				-789	-1,161		-1,325		
		-264	-725				-1,086	-1,421		-1,750		
45		-244	-902				-1,352	-2,015		-2,071		
		448	-1,051				-1,575	-2,395		-1,968		
		2,587	7,857	(3,244)	(-103)	-3,196	(-6,945)	(-1,926)		-1,711		
75			5,205	1,980		-4,009	-3,275	-856				
		507		78	-89	-361	-1,312	-1,214		-1,186		
105				181		965	1,233		479	217		

TABLE 13.- STRESSES AROUND SIDE CUTOUT OF 130° BY 2 BAYS IN CYLINDER LOADED BY SHEAR

FORCE OF 2,000 POUNDS AT TIP (ACTUAL APPLIED LOAD, 2,000 POUNDS) - Continued

(c) Shear stresses, psi

Distance from center line of cutout, in.													
	30	24	18	12	6	0	6	12	18	24	30		
15	-667	82							-762 -482				
									-761 -523				
									-770 -589				
	-787	-550							-765 -659				
45									-812 -742				
	-775	-1,537							-890 -832	-354	-336		
									-1,481				
75	-107	146			-2,727 -2,265	-2,348 -2,278	-2,379	1,689	206	233			
					-2,553	-2,534 -2,493	-1,825	-906	466				
105	284	-111			-643 -713	-577 -803	-660	-214	-325	190			
					618	577 474	-148	-297					
135													
		536			1,191	1,071 1,108							
165					1,096								
						1,112 1,166							

TABLE 13.- STRESSES AROUND SIDE CUTOUT OF 130° BY 2 BAYS IN CYLINDER LOADED BY SHEAR

FORCE OF 2,000 POUNDS AT TIP (ACTUAL APPLIED LOAD, 2,000 POUNDS) - Continued

(d) Shear stresses due to cutout only, psi

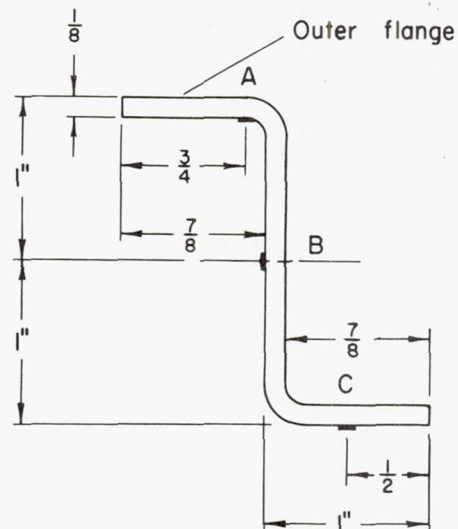
		Distance from center line of cutout, in.														
		30	24	18	12	6	0	6	12	18	24	30				
θ, deg	15												63	343		
		145		894									51	289		
													4	185		
		-73		164									-51	55		
													-180	-110		
	45	-245		-1,007									-360	-302	176	194
													-1,069			
	75	175		428		-2,445	-1,983	-2,066	-1,996	-2,097	1,971		488	515		
							-2,410	-2,391	-2,350	-1,682	-763		609			
105	141		254		-786	-856	-720	-946	-803	-257		-468	47			
						206		165	62	-560		-709				
135																
			-96			559		439	476							
165						322										
								300	354							

TABLE 13.- STRESSES AROUND SIDE CUTOUT OF 130° BY 2 BAYS IN CYLINDER

LOADED BY SHEAR FORCE OF 2,000 POUNDS AT TIP (ACTUAL

APPLIED LOAD, 2,000 POUNDS) - Concluded

(e) Ring stresses, psi



θ , deg	Ring 1			Ring 2		
	A	B	C	A	B	C
95	344	224	95	519	-848	-1,367
85	281	212	-26	-85	710	0
75	-148	---	21	-689	1,558	1,707
65				-1,632	2,533	3,498
55				-1,749	3,074	3,816
45				-2,279	2,533	3,371
35				-2,226	2,035	3,392
25				-1,929	1,463	2,417
15				-827	716	1,378
5				85	0	138
5				1,007	-1,505	-1,272
15				1,749	-742	-2,099
25				2,438	-1,908	-2,968
35				2,385	-2,353	-3,710
45				2,173	-2,544	-3,466
55				1,378	-2,067	-2,830
65				1,113	-1,208	-1,908
75	-175	---	138	106	-541	-424
85	-313	0	191	-498	477	1,345
95	-286	0	180	-1,166	1,420	2,170

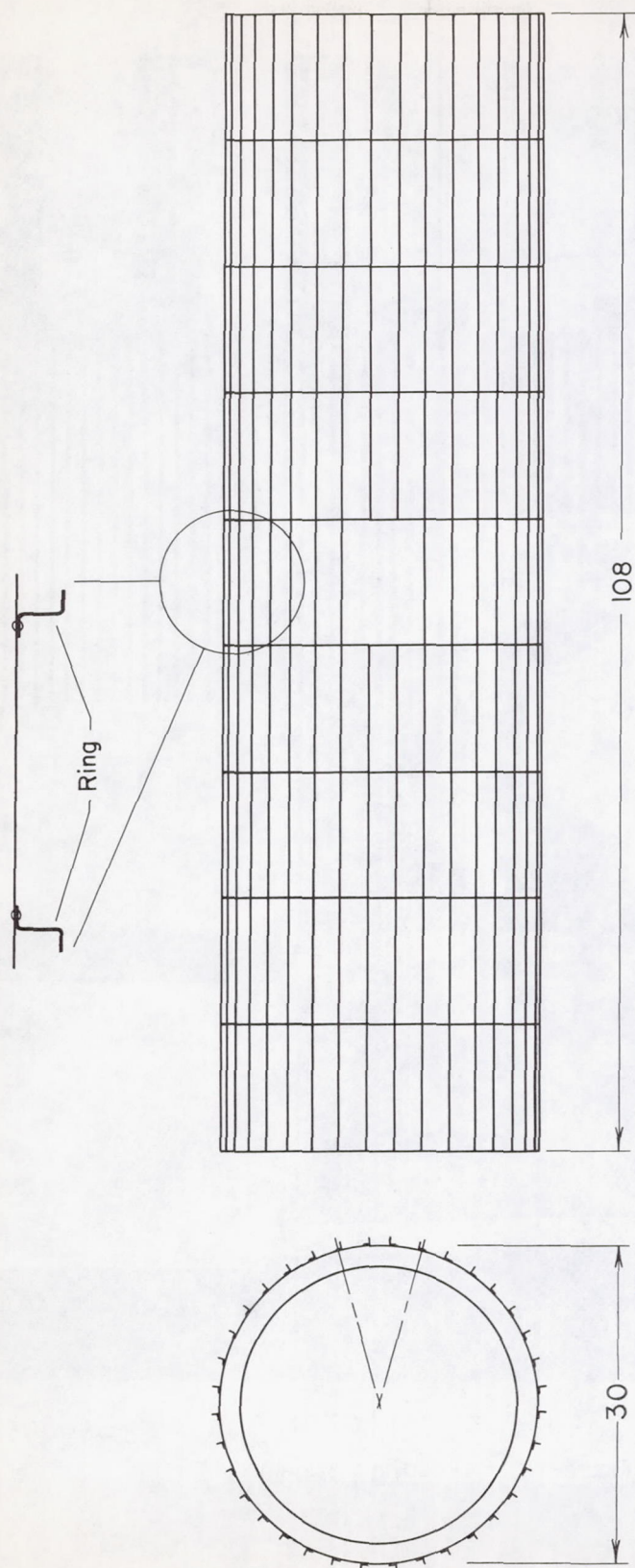
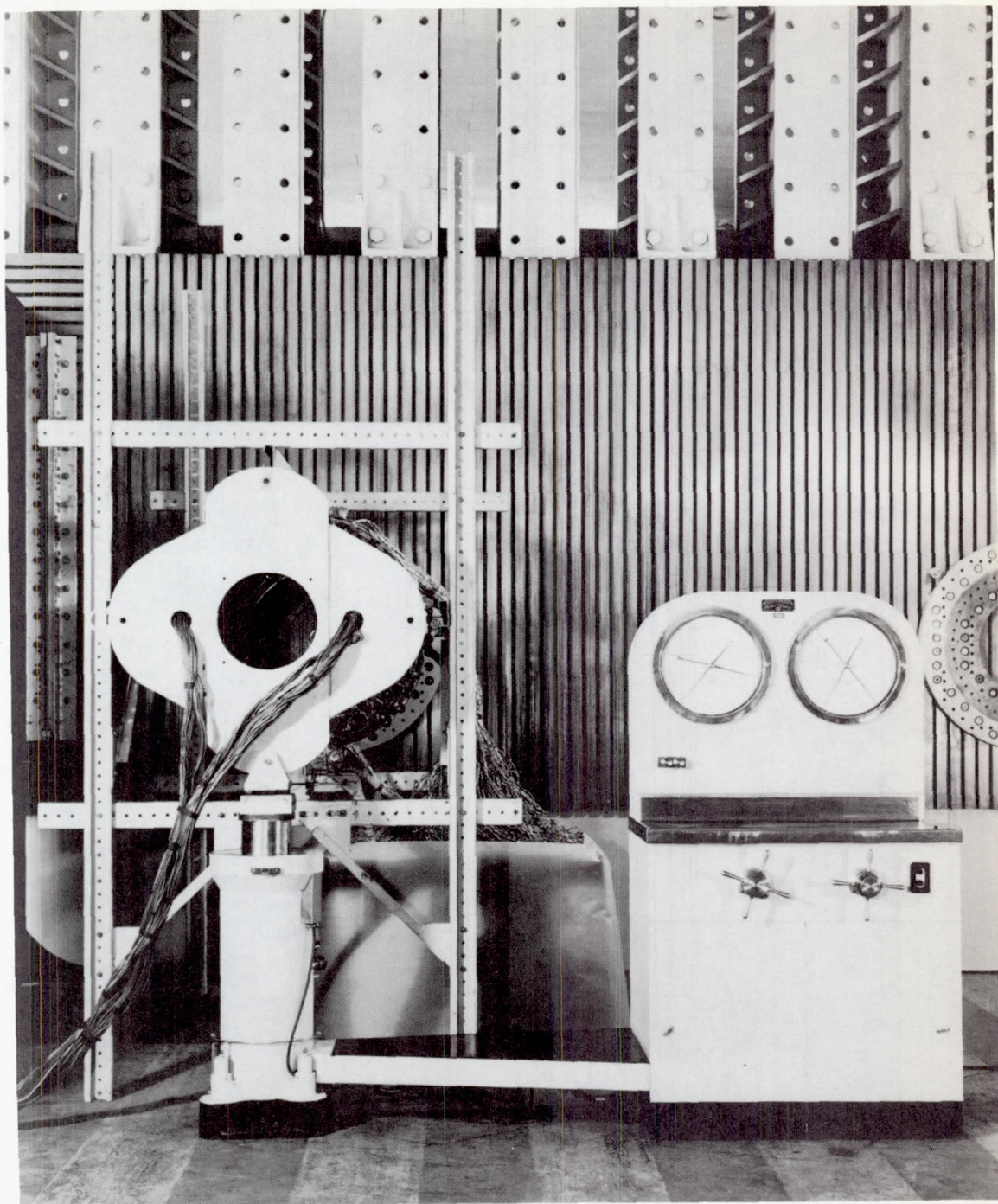
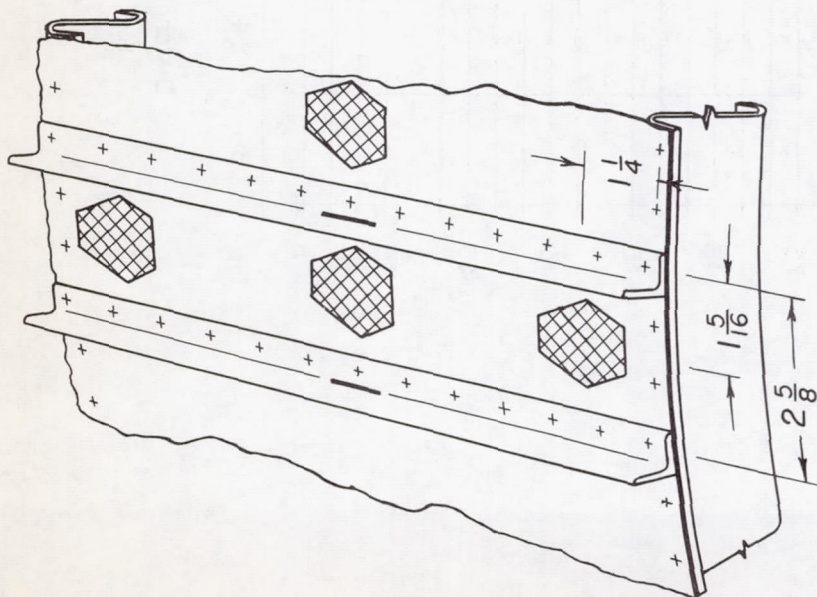


Figure 1. - Test specimen.

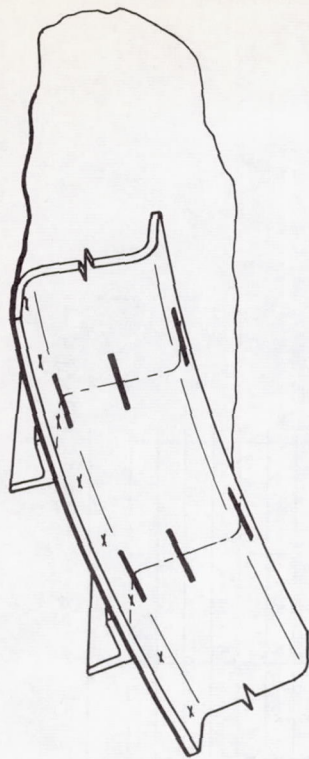


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Figure 2. - Loading system.

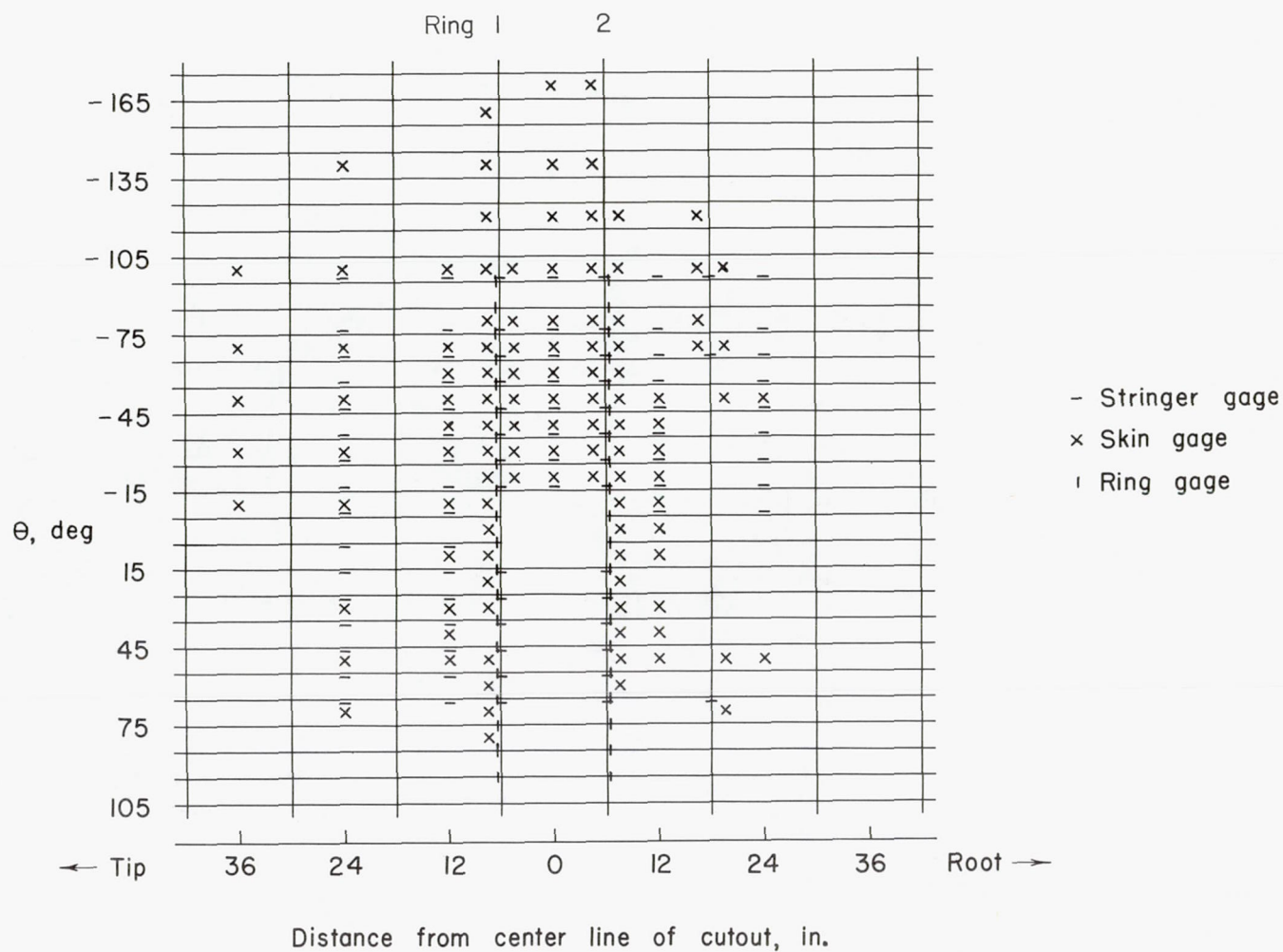


(a) Stringer and skin gages.



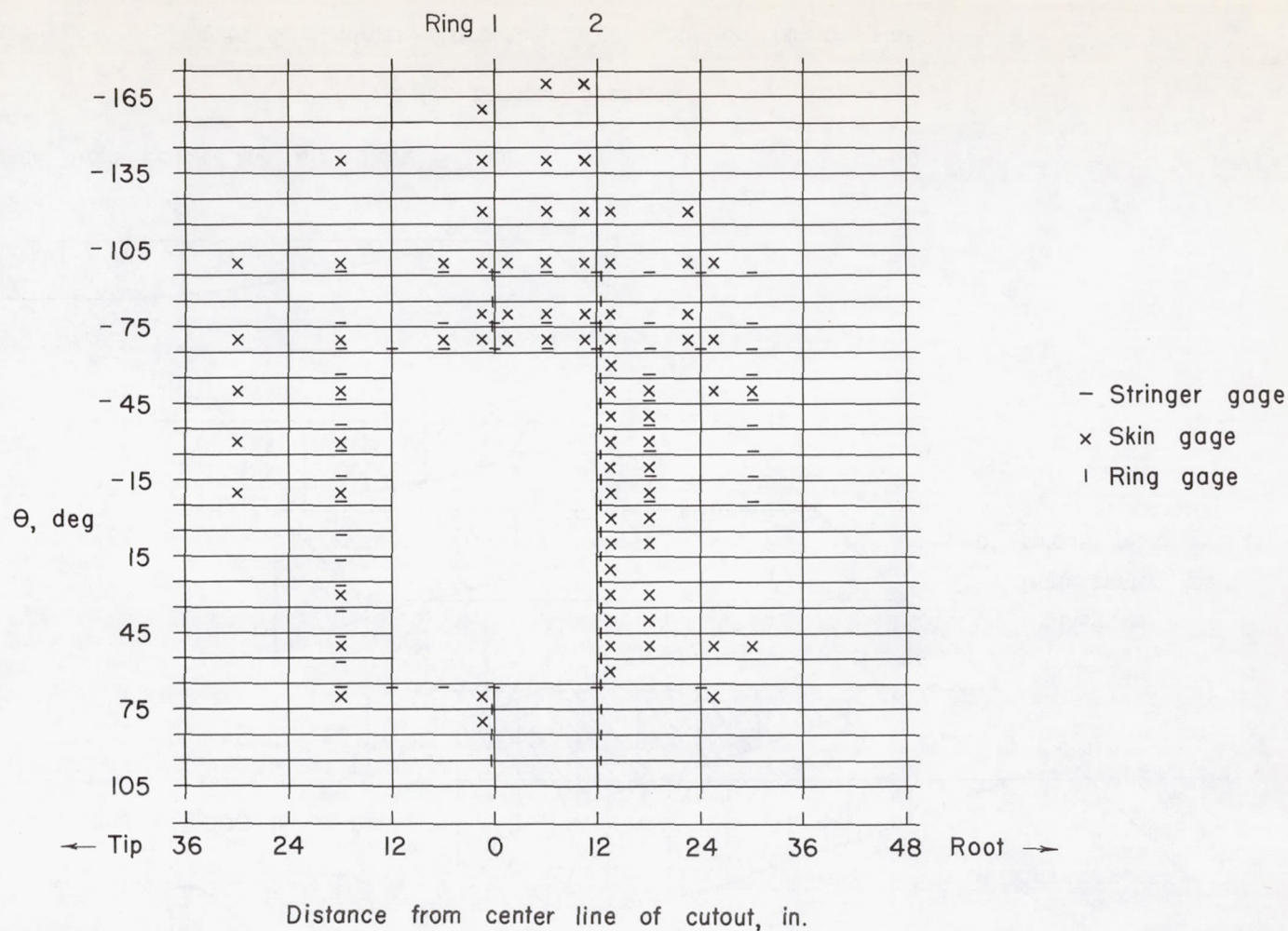
(b) Ring gages.

Figure 3. - Typical gage mountings.



(a) Cutout I bay long.

Figure 4.-Gage pattern.



(b) Cutout 2 bays long.

Figure 4.- Concluded.

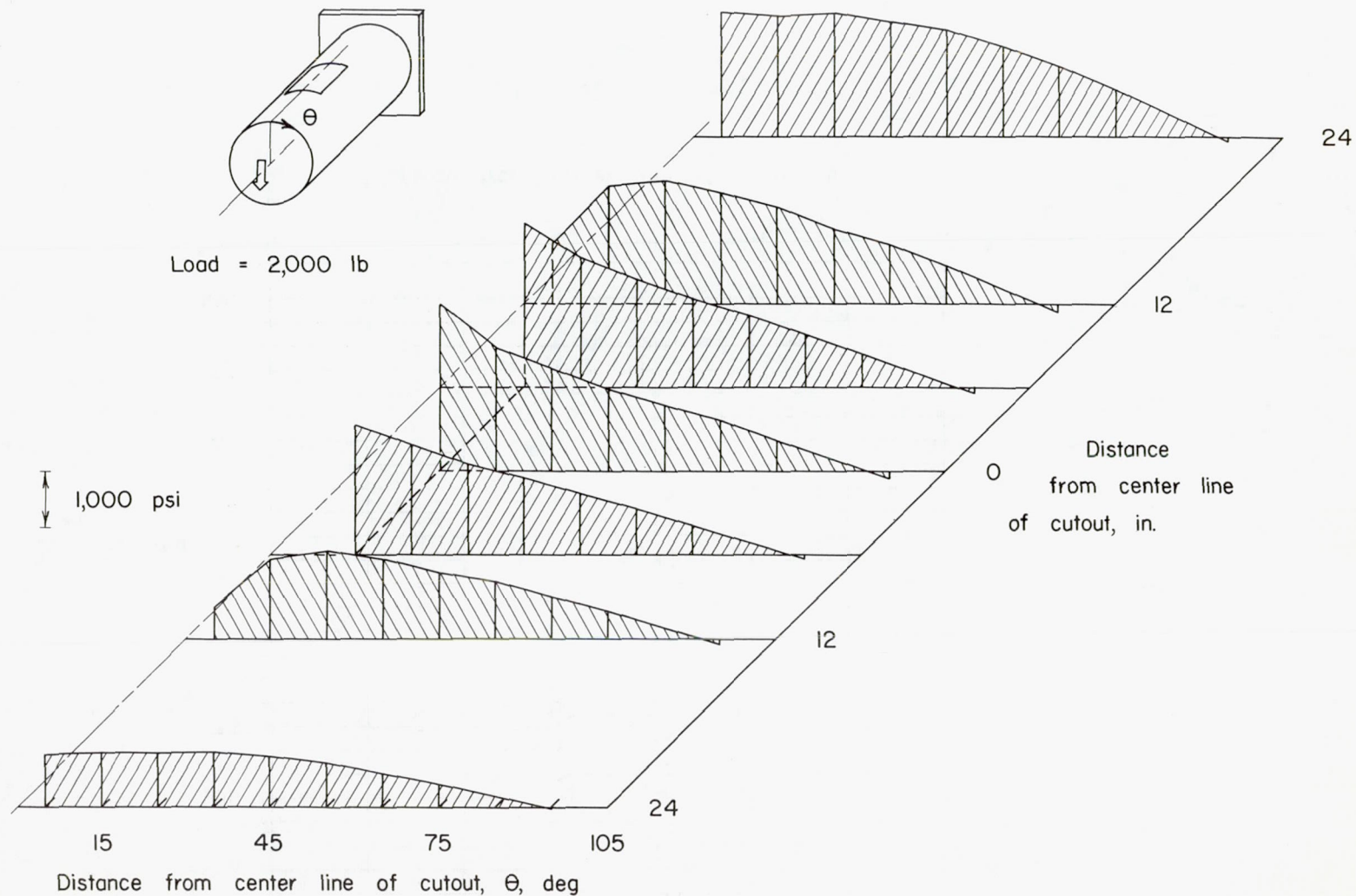
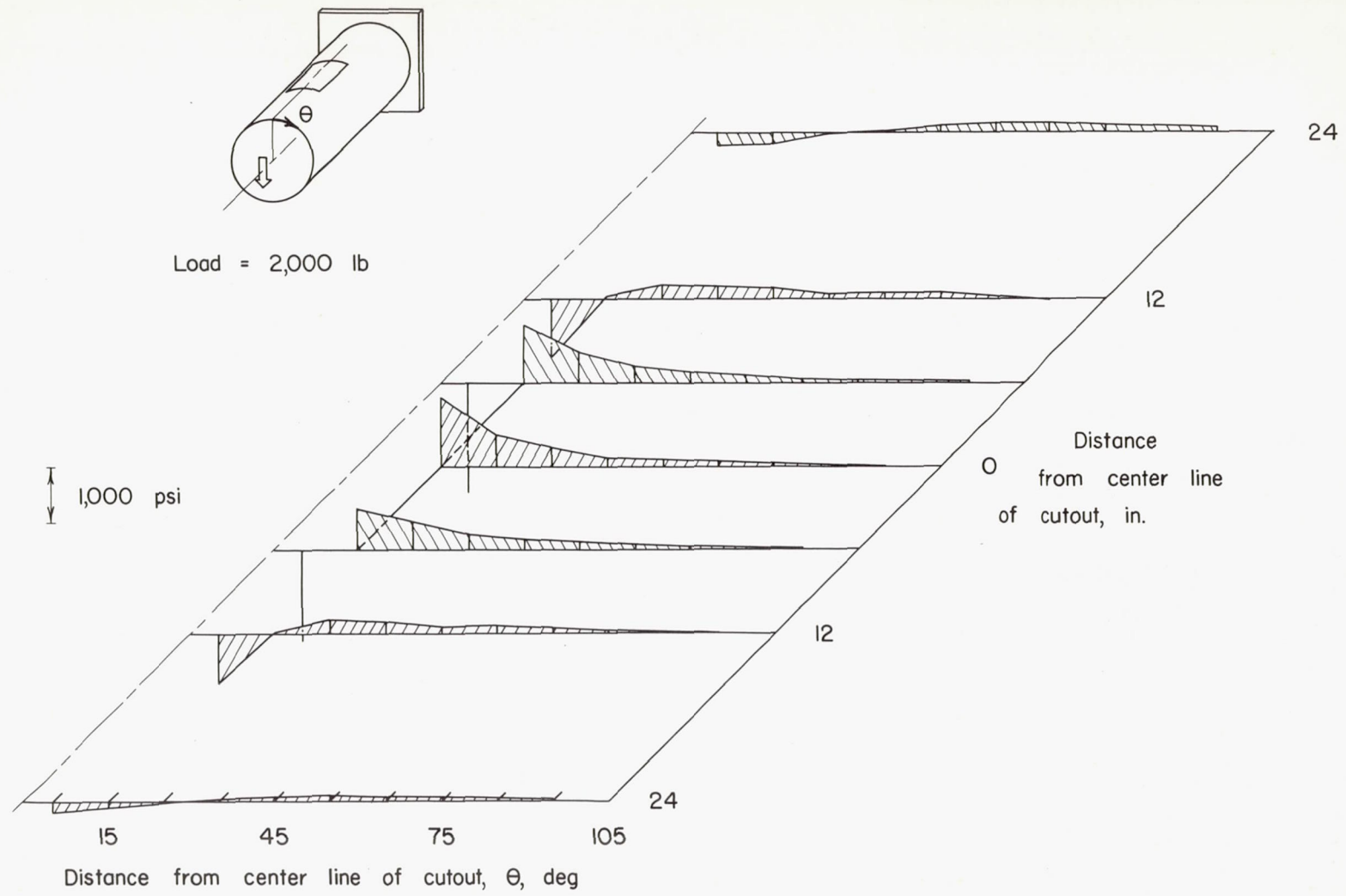
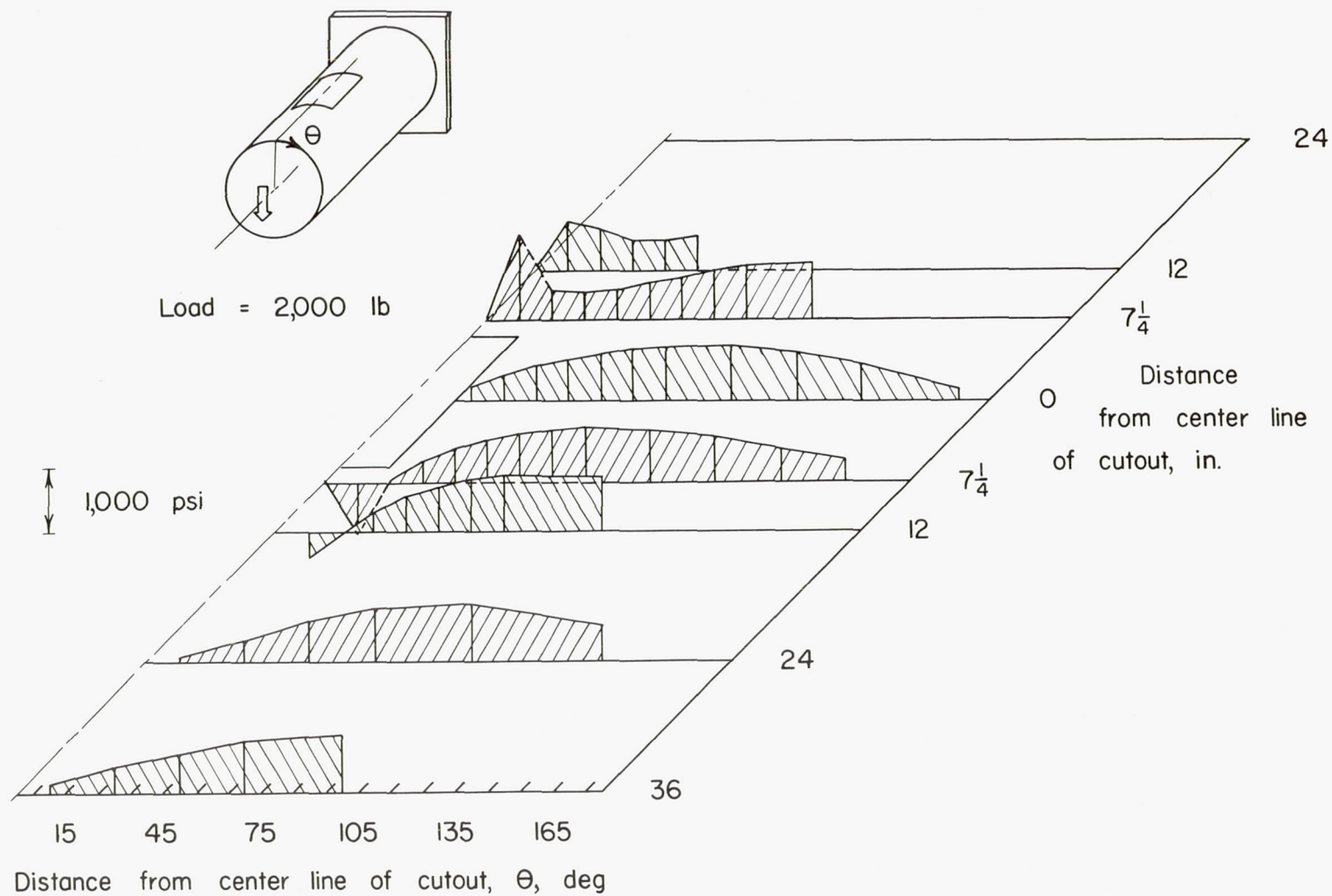


Figure 5. - Stress distribution, 30° cutout on tension side.



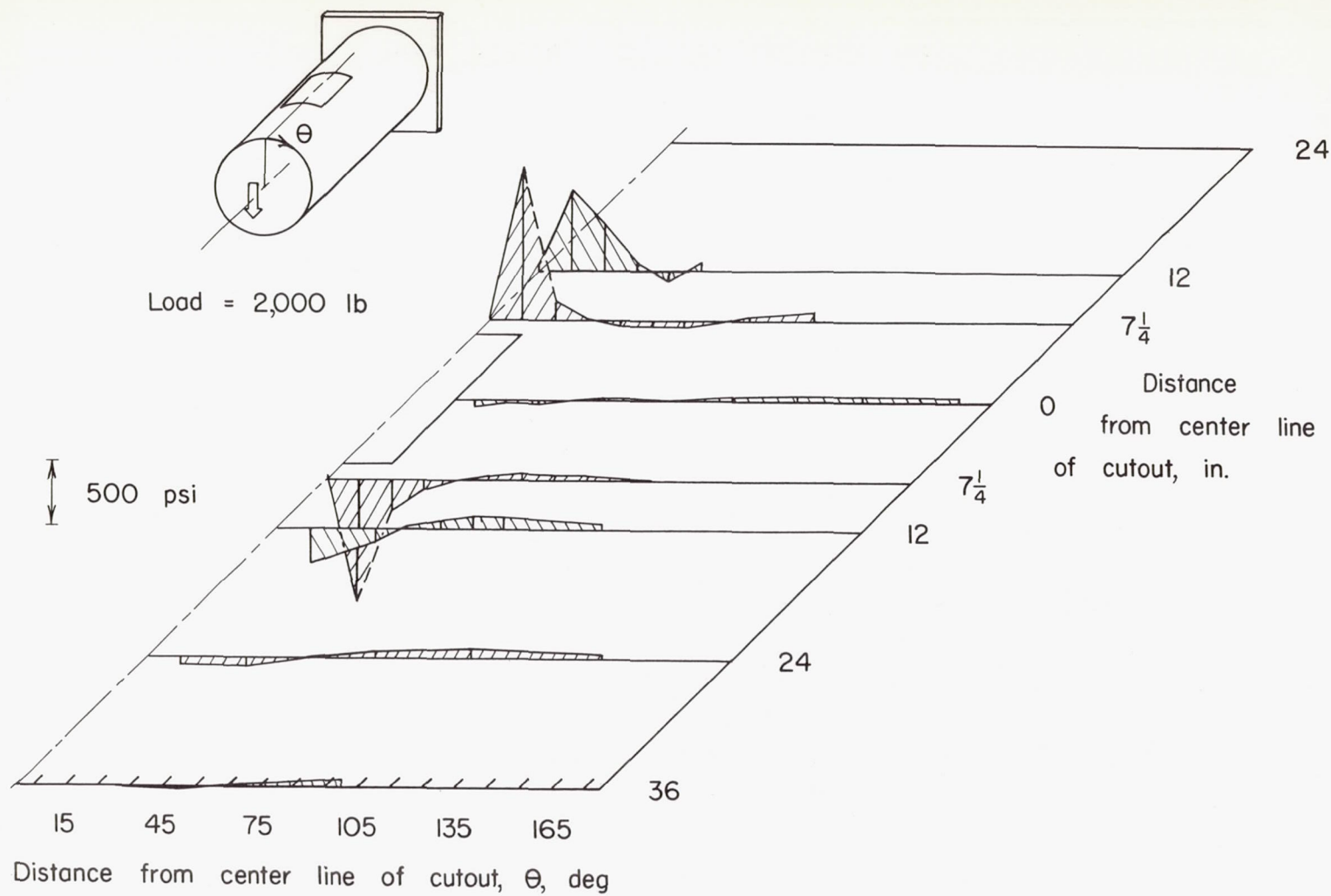
(b) Stringer stresses due to cutout only.

Figure 5. - Continued.



(c) Shear stresses.

Figure 5. - Continued.



(d) Shear stresses due to cutout only.

Figure 5. - Concluded.

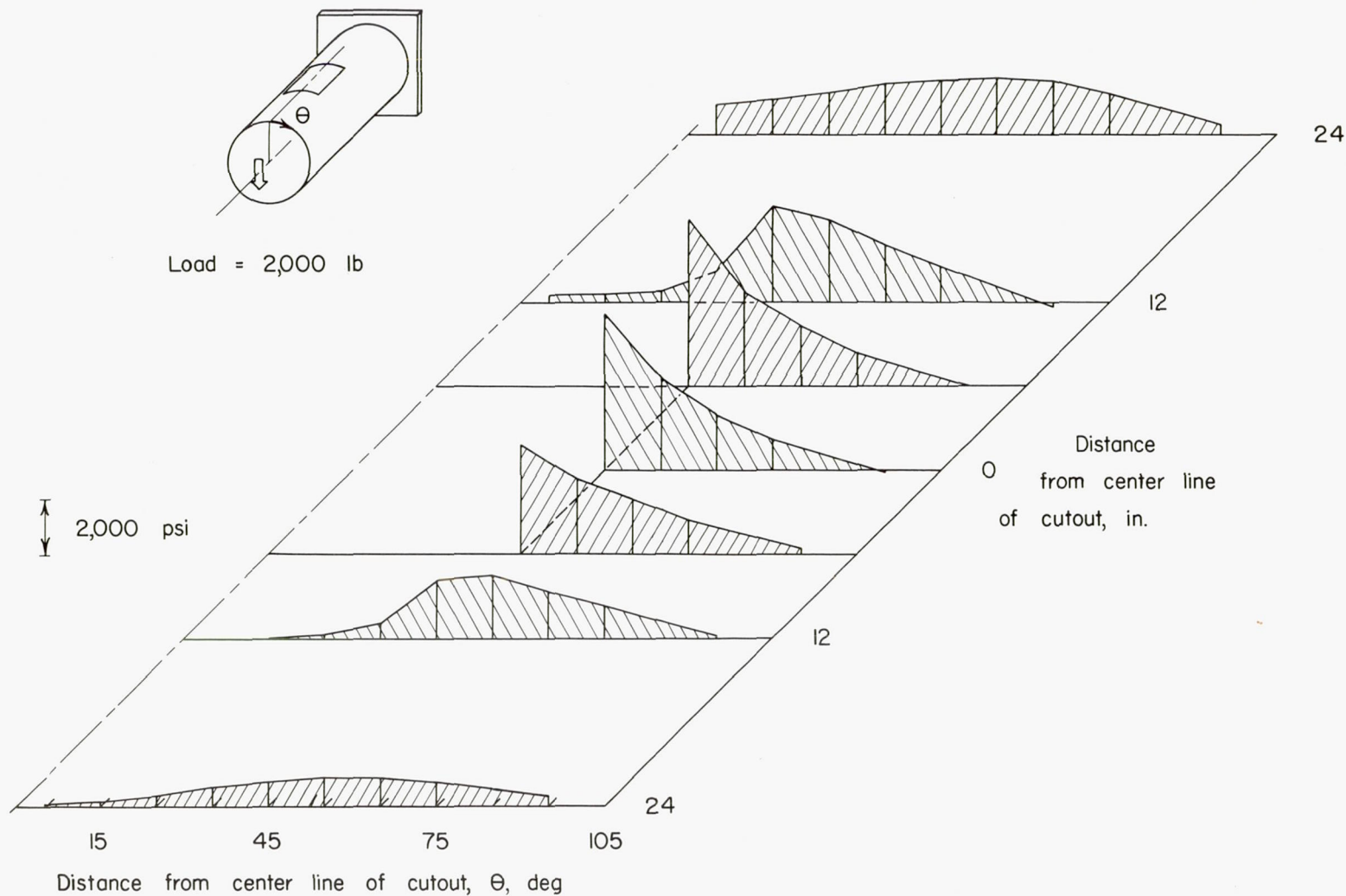
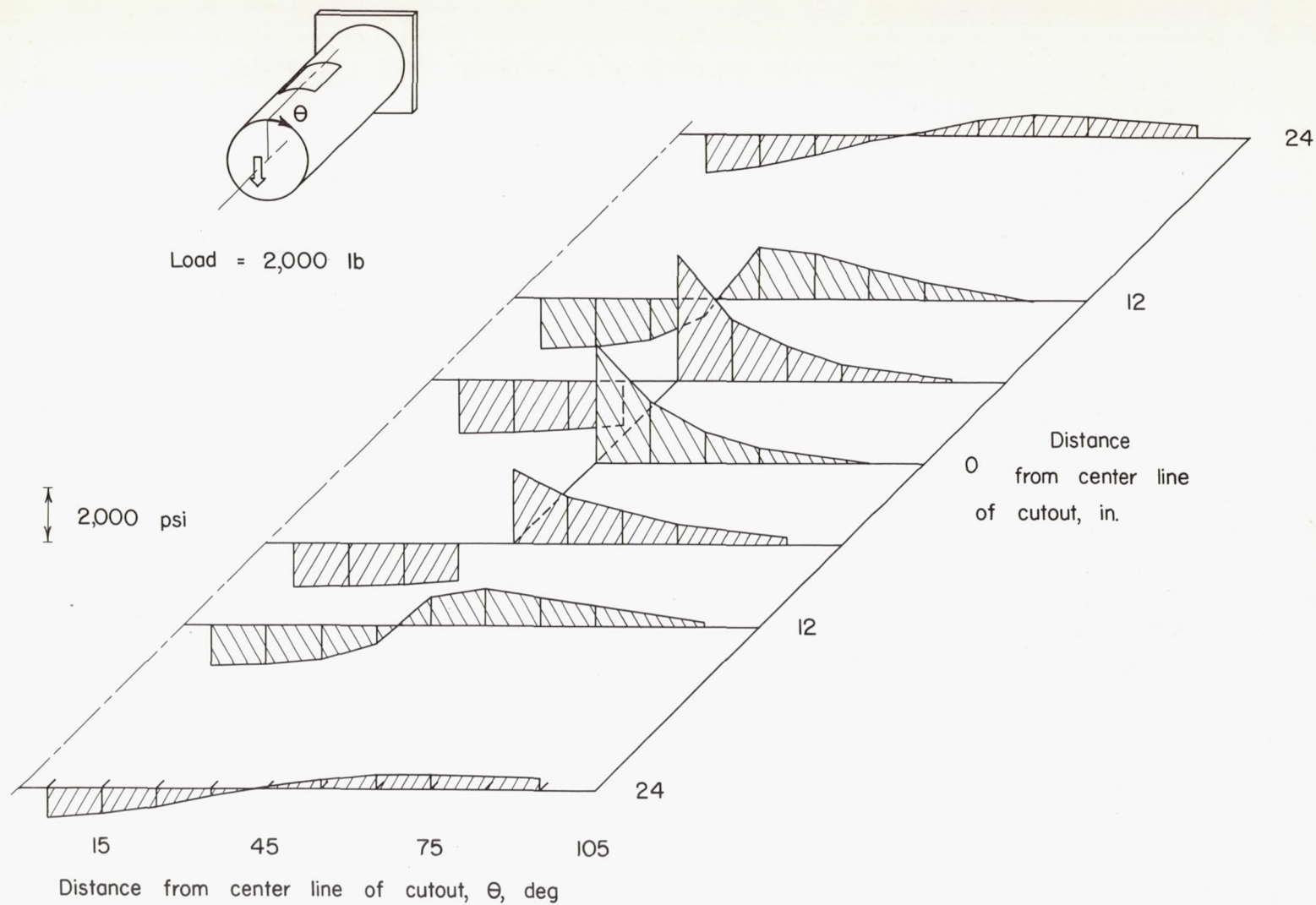
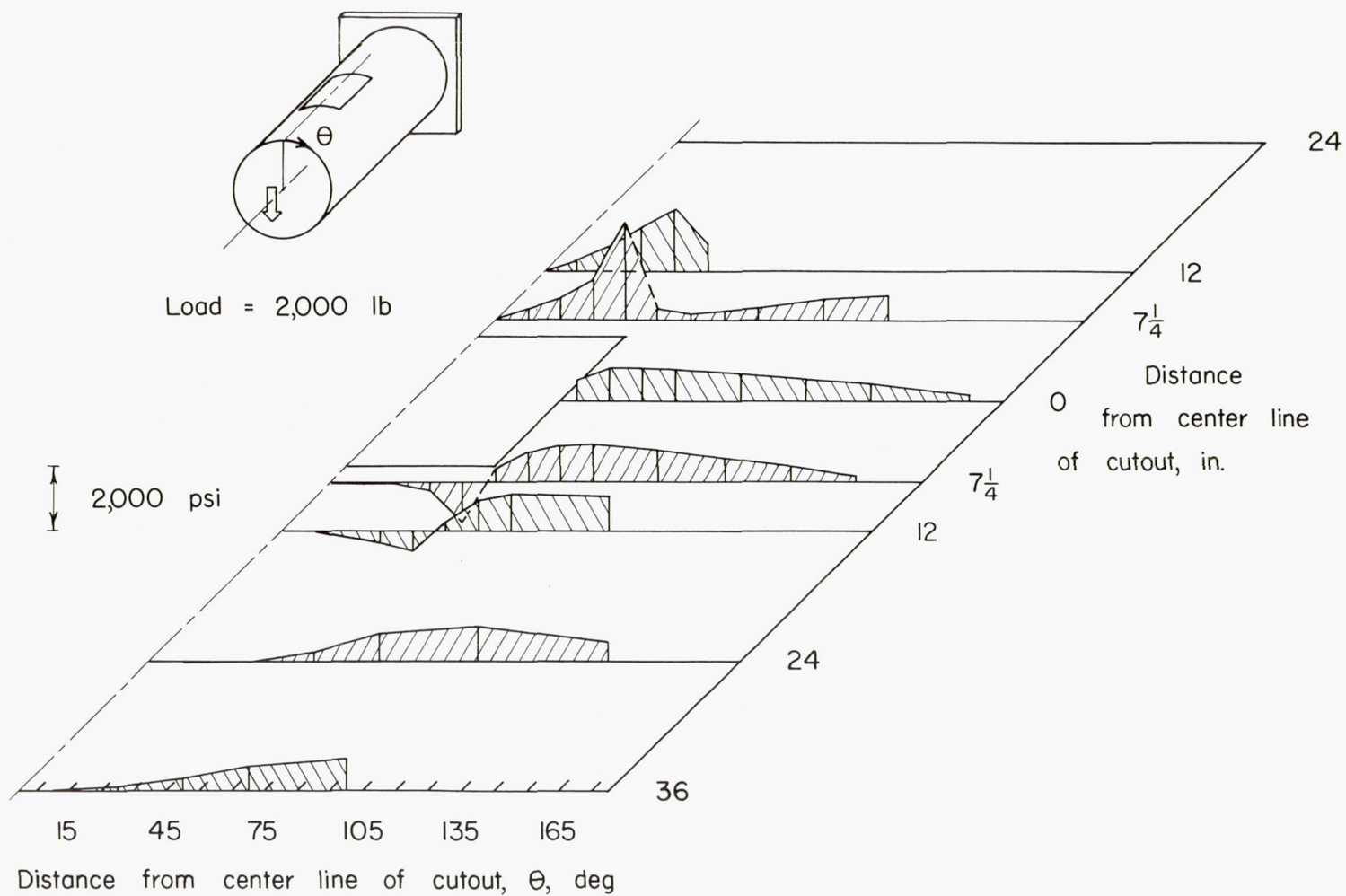


Figure 6. - Stress distribution, 90° cutout on tension side.



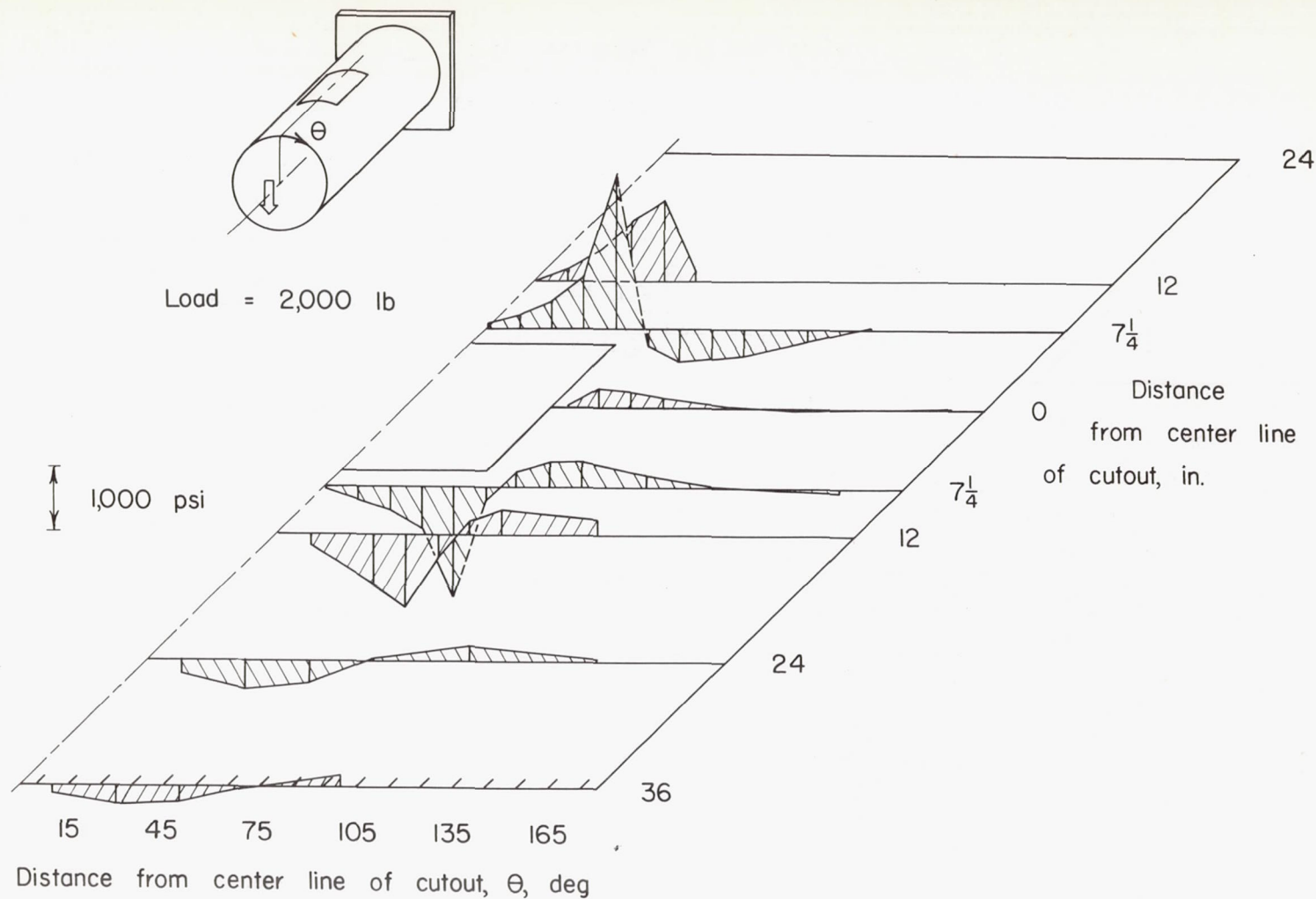
(b) Stringer stresses due to cutout only.

Figure 6. - Continued.



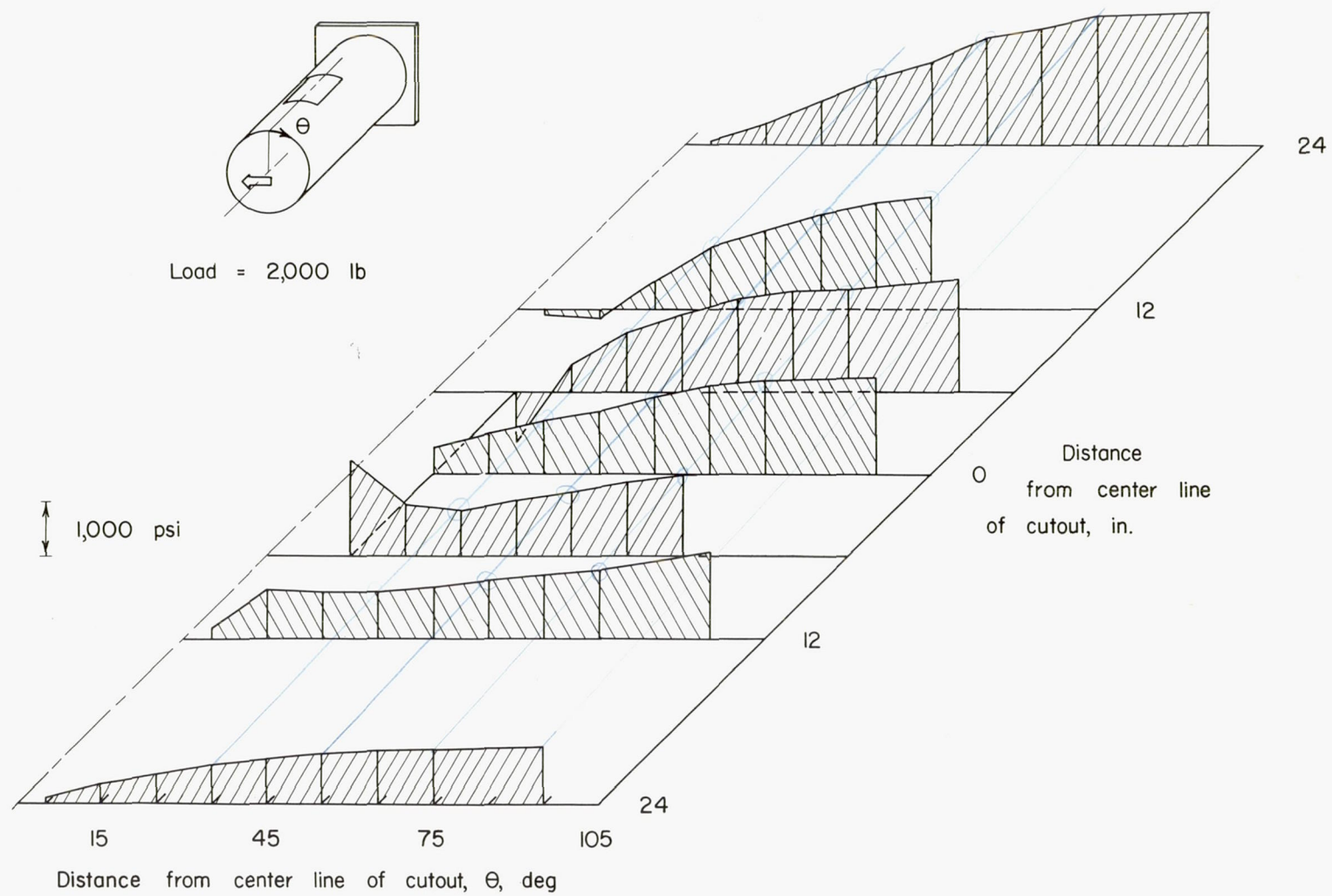
(c) Shear stresses.

Figure 6. - Continued.



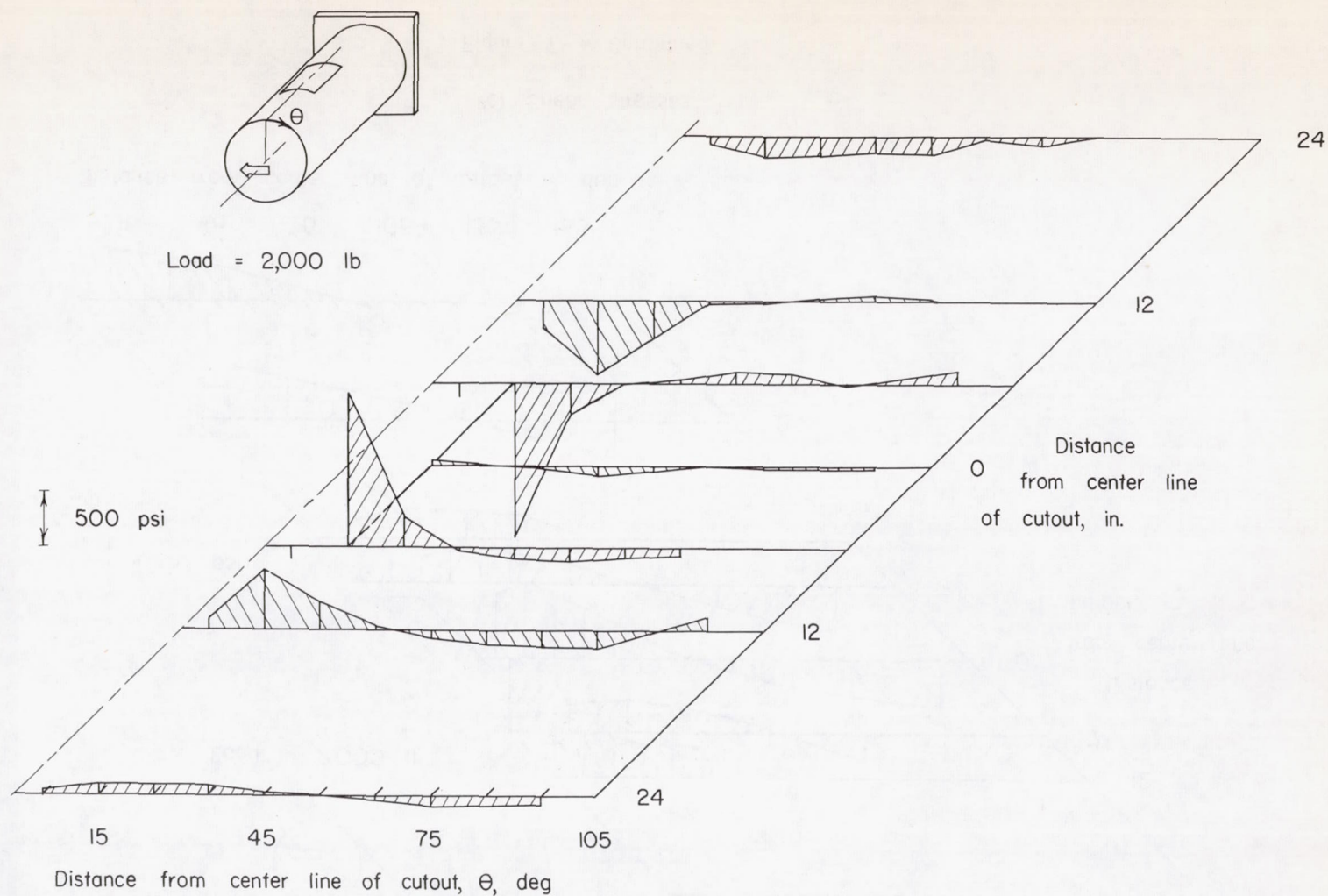
(d) Shear stresses due to cutout only.

Figure 6. - Concluded.



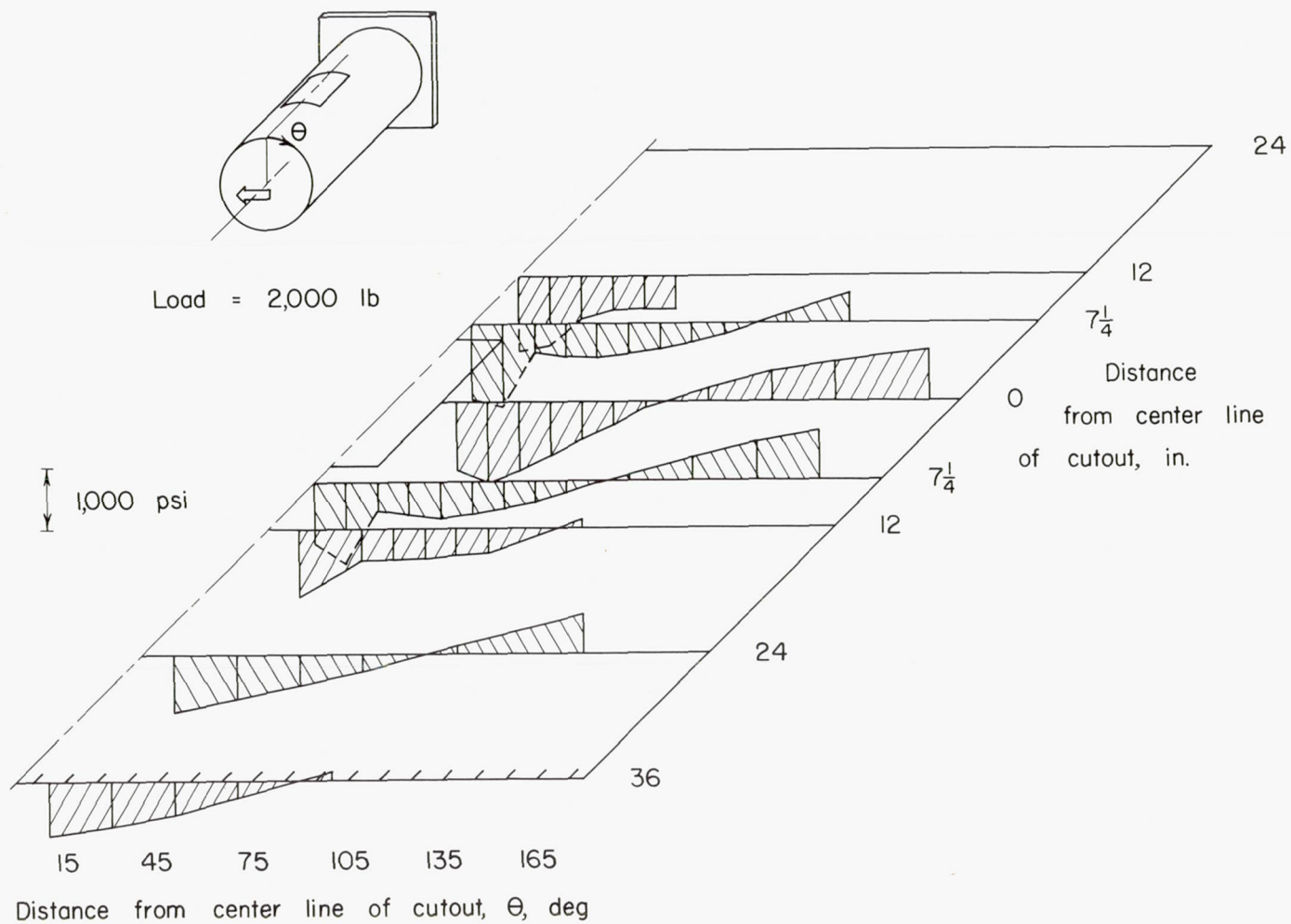
(a) Stringer stresses.

Figure 7 - Stress distribution, 30° side cutout.



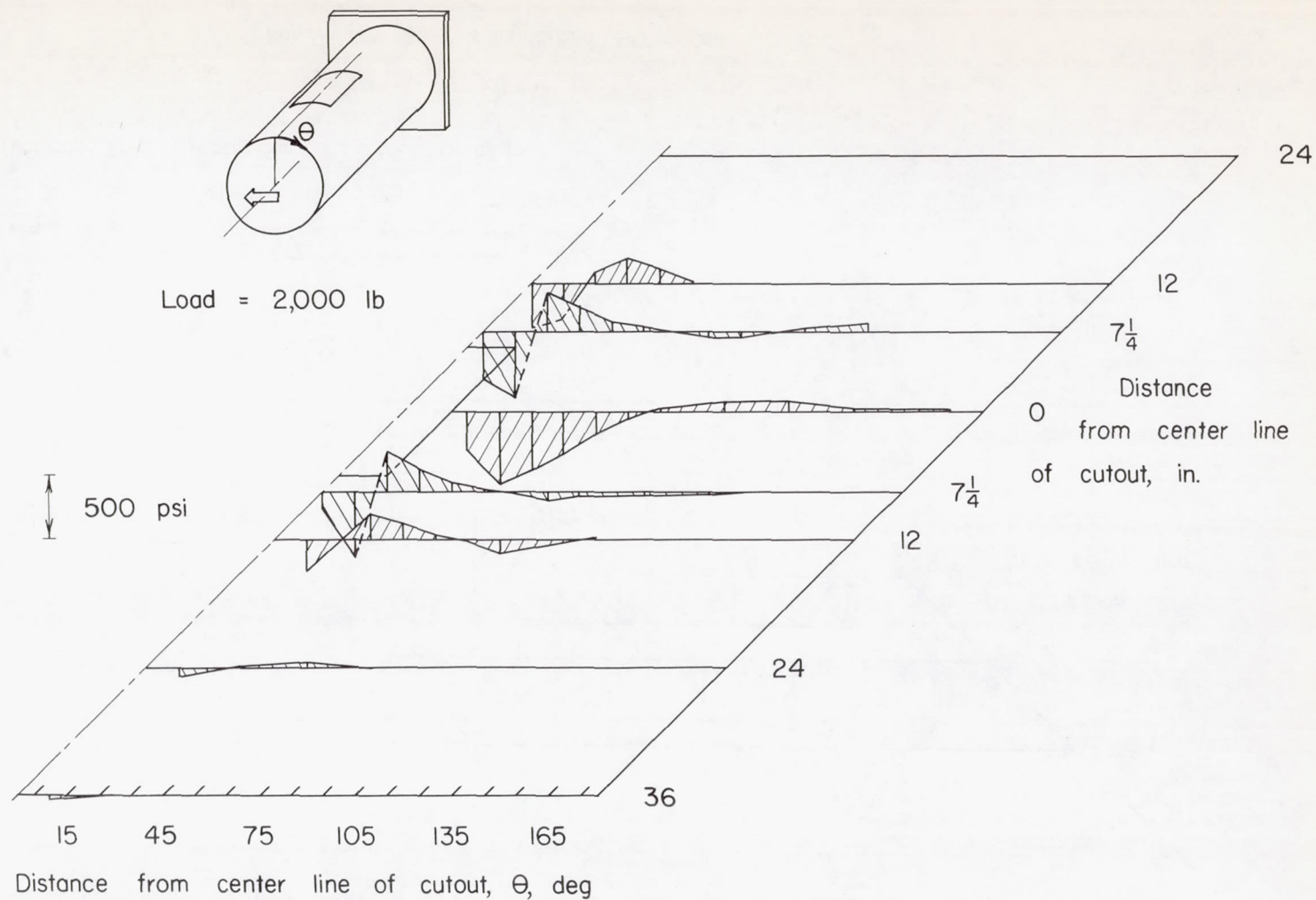
(b) Stringer stresses due to cutout only.

Figure 7. - Continued.



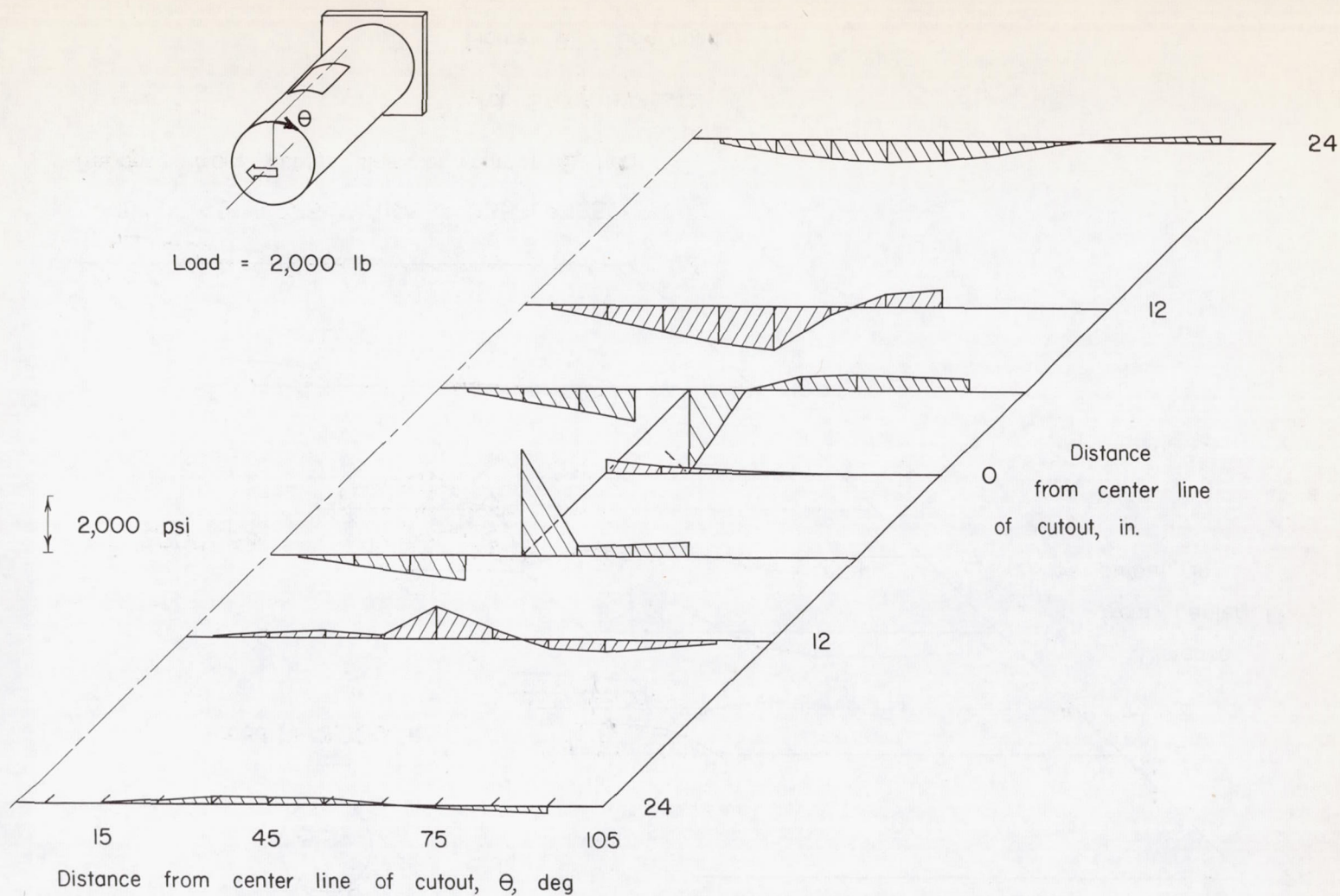
(c) Shear stresses.

Figure 7. - Continued.



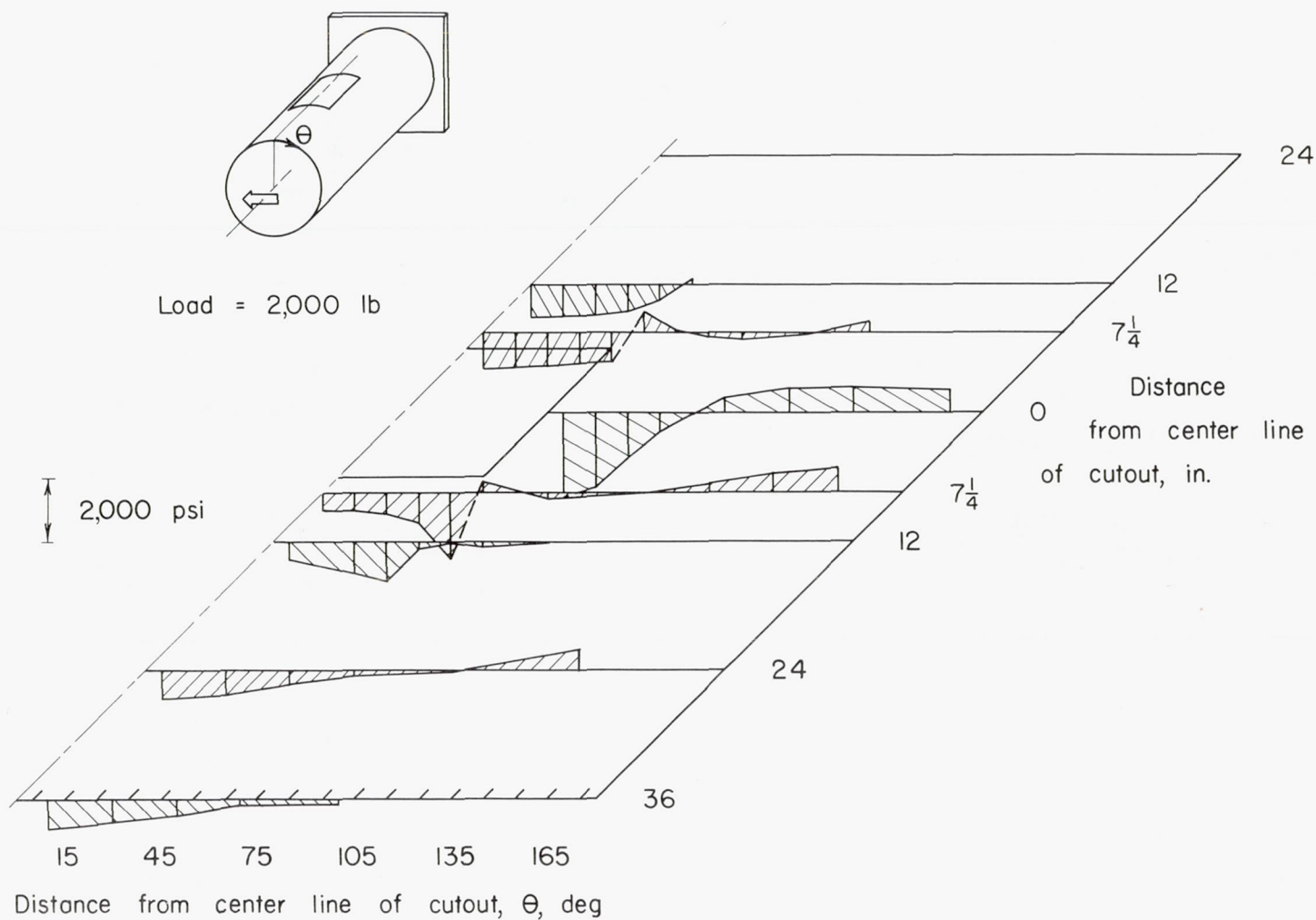
(d) Shear stresses due to cutout only.

Figure 7. - Concluded.



(b) Stringer stresses due to cutout only.

Figure 8. - Continued.



(c) Shear stresses.

Figure 8. - Continued.

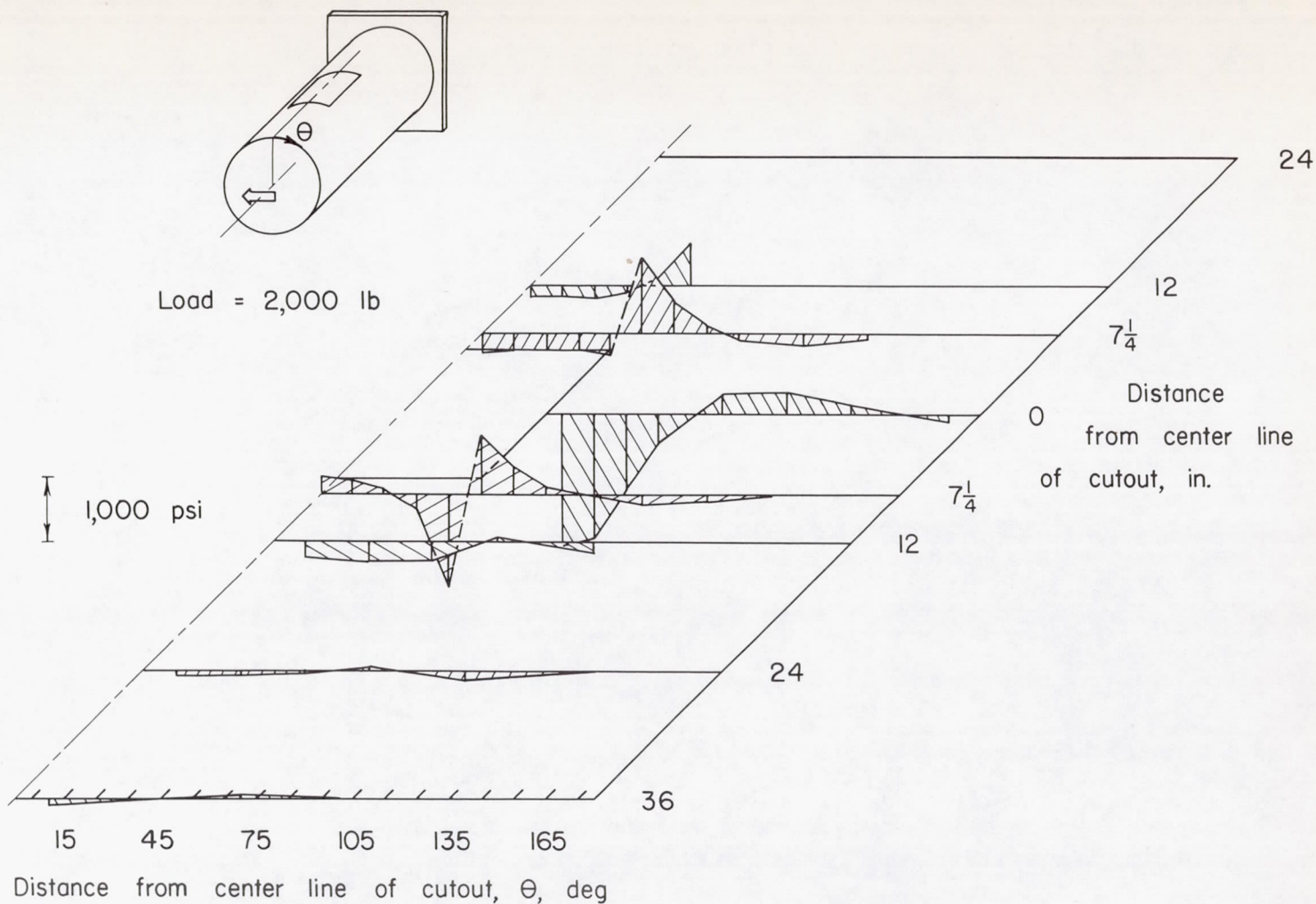


Figure 8. - Concluded.